Marine Fisheries
REVIEW
Vol. 55, No. 3
1993
National Oceanic and Atmospheric Administration • National Marine Fisheries Service

Pacific Whiting

Marine Fisheries REVIEW

On the cover:
A catch of Pacific whiting.

Articles *55(3), 1993*

Temporal and Spatial Distribution of Catches of Tiger Sharks, *Galeocerdo cuvier*, in the Pelagic Longline Fishery Around the Hawaiian Islands — *Jeffrey J. Polovina* and *Boulderson B. Lau* **1**

Comparisons of Shark Catch Rates on Longlines Using Rope/Steel (Yankee) and Monofilament Gangions — *Steven Branstetter* and *John A. Musick* **4**

Inhibition of Protease Activity in Muscle Extracts and Surimi from Pacific Whiting, *Merluccius productus*, and Arrowtooth Flounder, *Atheresthes stomias* — *Roy W. Porter*, *Barbara Koury*, and *George Kudo* **10**

Charter and Party Boat Operators in the U.S. Gulf of Mexico: A Social Structure Perspective — *Duane A. Gill*, *Robert B. Ditton*, and *Stephen M. Holland* **16**

A Social and Economic Characterization of the U.S. Gulf of Mexico Recreational Shark Fishery — *Mark R. Fisher* and *Robert B. Ditton* **21**

U.S. DEPARTMENT OF COMMERCE

Ronald H. Brown, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

D. James Baker, Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service

Rolland A. Schmitten, Assistant Administrator for Fisheries

Editor: W. L. Hobart

The *Marine Fisheries Review* (ISSN 0090-1830) is published quarterly by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., BIN C15700, Seattle, WA 98115. Annual subscriptions are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402: Annual subscription $7.00 domestic, $8.75 foreign. For new subscriptions write: New Orders, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954.

Publication of material from sources outside the NMFS is not an endorsement and the NMFS is not responsible for the accuracy of facts, views, or opinions of the sources. The Secretary of Commerce has determined that the publication of this periodical is necessary for the transaction of public business required by law of this Department. Use of the funds for printing this periodical has been approved by the Director of the Office of Management and Budget.

The NMFS does not approve, recommend, or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to NMFS, or to this publication furnished by NMFS, in any advertising or sales promotion which would indicate or imply that NMFS approves, recommends, or endorses any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this NMFS publication.

Second class postage is paid in Seattle, Wash., and additional offices. POSTMASTER: Send address changes for subscriptions for this journal to—*Marine Fisheries Review*, c/o Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Temporal and Spatial Distribution of Catches of Tiger Sharks, *Galeocerdo cuvier*, in the Pelagic Longline Fishery Around the Hawaiian Islands

JEFFREY J. POLOVINA and BOULDERSON B. LAU

Introduction

The tiger shark, *Galeocerdo cuvier*, has a circumglobal distribution in tropical and temperate oceans (Randall, 1992). While considered a nearshore shark, returns of tagged tiger sharks from the east coast of the United States show that they can move considerable distances. The Cooperative Shark Tagging Program of the NMFS Northeast Fisheries Center's Naragansett Laboratory tagged 2,257 tiger sharks during 1977-89 and have data from the recoveries of 135 tags (Randall, 1992). Fifty-seven tags were recovered at least 100 n.mi. away from the tagging sites. The greatest distance between the tag and recovery sites was 1,853 n.mi. (Randall, 1992). Generally, this movement is believed to be alongshore movement over the continental shelf.

Less is known about tiger shark movement in the oceanic Hawaiian Islands. In one tagging study only four tagged tiger sharks have been recovered, and only one showed any significant movement, 45 n.mi., from the north to the south of the Island of Oahu (Tester, 1969). Sonic tracking of a tiger shark in the Northwestern Hawaiian Islands over two 24-hour periods found the shark remained within 7 km of the reef (Tricas et al., 1981).

As a result of recent apparent increases in tiger shark attacks on humans in Hawaii (Balazs, In press), there is considerable interest in long-term movement patterns of tiger sharks around the Hawaiian Islands. Information on the movement of tiger sharks around the Archipelago would provide a useful biological background to assess the impact of management actions such as localized shark fishing.

Since November 1990, the Honolulu Laboratory of the NMFS Southwest Fisheries Science Center has collected logbooks from vessels fishing in the pelagic longline fishery around the Hawaiian Archipelago. Occasionally, catches of tiger sharks are recorded in the logbooks and these records provide unique information on the offshore occurrence of tiger sharks around the Hawaiian Islands. Here, we present a spatial and temporal analysis of catches of tiger sharks from the longline fishery logbooks.

Data

Fish are caught by longline gear with baited hooks on hundreds of branch lines attached to a single long main line often stretching 30 n.mi. The main line is buoyed at regular intervals by float lines connected to surface floats. The depth of the hooks alters the gear efficiency in catching different species. Each longline set requires most of a day or night to set, soak, and retrieve. Recently, because of the development of the swordfish fishery, the longline fleet has grown dramatically, and many vessels often make from 30- to 40-day trips, traveling 400-1,000 miles north of Hawaii. The longline fishery around the Hawaiian Archipelago typically targets swordfish and bigeye tuna but catches a wide range of fishes occasionally including tiger sharks. Longline sets targeting tunas are usually day sets; gear is deployed early in the morning and retrieved late in the afternoon. Sets targeting swordfish are night sets; gear is set late in the afternoon and retrieved early in the morning. Since November 1990, all longline vessels fishing around the Hawaiian Islands are required to report by set: Location of the set, number of hooks, and number of fish caught for the 15 most common species, including three species of oceanic sharks. Tiger sharks are not one of the species specifically identified in the logbooks; they are entered as "other" on the log sheets.

Logbooks from December 1990 to May 1993 were examined for reports of tiger shark catches. During this 30-month period, longlining within 50 n.mi. of the main Hawaiian Islands was prohibited for about 20 months (from mid-June to mid-December 1991 and from March 1992 to May 1993) to resolve gear conflicts.

Results

An examination of longline logbooks from December 1990 to May 1993 found 35 catches of tiger sharks recorded from 4,350 fishing trips (Table 1, Fig. 1).

The authors are with the Honolulu Laboratory, Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA 2570 Dole Street, Honolulu, HI 96822-2396.

ABSTRACT—Thirty-five tiger sharks, Galeocerdo cuvier, *have been reported caught in pelagic longline gear from 25 to 265 n.mi. off the Hawaiian Archipelago during December 1990-May 1993. Fifteen sharks were caught farther than 50 n.mi. offshore, indicating that tiger sharks do occur well offshore and removed from benthic topography. About 89% of the sharks were caught during October-March, while only 56% of the fishing effort occurred during that period.*

Tiger sharks were caught both on day longline sets targeting tunas and night longline sets which target swordfish (Table 1). Fifteen of the catches occurred both south and north of the Archipelago beyond 50 n.mi. offshore, with the farthest at 335 n.mi. offshore (Table 1, Fig. 1). Eighteen occurred within 45 n.mi. of the north side of Maui between November 1992 and January 1993 (Table 1, Fig. 1). About 89% (31 of 35) of the sharks were caught during the 1st and 4th quarters (October-March), while only 56% of the fishing trips occurred during this period (Table 2). Based on a chi-squared test the catches of tiger sharks in the 1st and 4th quarters are greater than would be expected if catches were proportional to fishing trips ($P<0.0001$). When the catch is examined based on distance offshore we find that 60% of those caught beyond 50 n.mi. offshore are caught in the 1st quarter (Table 2).

Table 1.—Reports of catches of tiger sharks from pelagic longline logbooks[1]. The coordinate for each location is the mean between set location and haul location. Distance is from the nearest shore of the Hawaiian Archipelago.

Record	Haul date	Set time	Haul time	Location Lat.	Location Long.	No. of tiger sharks	Distance from nearest shore (n.mi).	Quarter
1	930307	0700h	1800h	21° 56'	164° 41'	1	95	1
2	930304	0700	1800	21 46	164 37	1	105	1
3	930303	0730	1700	21 57	164 43	2	201	1
4	930119	0930	1730	18 54	160 20	1	165	1
5	930117	0900	1730	18 54	159 52	2	170	1
6	930117	0700	1730	21 12	155 47	1	30	1
7	921223	0750	1500	19 07	159 46	1	150	4
8	921222	0735	1430	19 27	160 41	1	104	4
9	921201	0800	1600	21 38	156 08	1	45	4
10	921126	0700	1600	21 32	156 01	1	35	4
11	921117	0800	1600	21 16	155 45	5	30	4
12	921116	0830	1600	21 17	156 00	4	25	4
13	921114	0800	1600	21 18	155 58	3	25	4
14	921113	0800	1600	21 22	155 51	3	35	4
15	920829	0630	1450	19 40	158 52	1	105	3
16	920811	1800	600	27 06	157 28	1	315	3
17	920209	830	1630	21 28	160 38	1	30	1
18	920117	610	1610	20 30	150 45	1	240	1
19	910626	1800	730	27 24	163 31	1	250	2
20	910617	1830	730	26 45	166 02	1	180	2
21	910329	1845	1030	28 19	159 05	1	365	1
22	910129	1400	0800	23 05	162 54	1	45	1

[1] Data provided by the Pelagics Fishery Management Plan of the Western Pacific Regional Fishery Management Council and compiled by the Fishery Management Research Program, SWFSC Honolulu Laboratory.

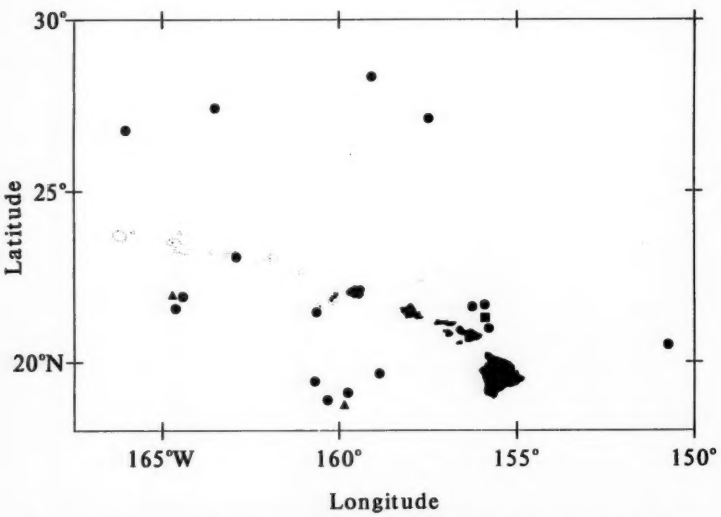

Figure 1.—Locations of tiger sharks caught by the longline fishery based on longline logbooks during December 1990-May 1993. Dots represent catches of a single tiger shark per longline set, triangles represent catches of more than one tiger shark per longline set, and the square represents four sets each with a catch of more than one tiger shark.

Discussion

Since tiger sharks are rarely caught on longline gear and since reporting requires that the incident be entered on the log sheet, it is likely that the reported catches underestimate actual catches. In fact, discussions with captains of vessels not reporting tiger shark catches in the logbooks confirm that other vessels have caught tiger sharks, but they have not specifically reported the catch. We cannot confirm that all tiger sharks reported were actually tiger sharks, but since tiger sharks are easily identified, it is likely that anyone interested enough to take the time to note the catch of a tiger shark would be able to correctly identify the species.

The reported catches show that tiger sharks can be found far offshore and well away from topographic features. Bottom depths even just 25 n.mi. off most of the islands exceed 4,000 m. Certainly, movement along the entire length of the Hawaiian Archipelago would be possible given these offshore movements. The higher catches of tiger sharks during the 1st and 4th quarters and, specifically, the higher catches of tiger sharks beyond 50 n.mi. during the 1st quarter suggest some seasonal offshore movement pattern. However, a more rigorous experimental design is needed to evaluate this hypothesis. The catches of 18 tiger sharks within 45

Table 2.—Tiger shark catches and fishing trips by quarter from the pelagic longline logbooks, December 1990–May 1993.

	Quarter of the Year 1	2	3	4
Fishing Trips	1,569	1,207	689	885
Tiger Sharks				
less than n.mi. offshore	3	0	0	17
more than 50 n.mi. offshore	9	2	2	2
Total Tiger Sharks	12	2	2	19

Data provided by the Pelagics Fishery Management Plan of the Western Pacific Regional Fishery Management Council and compiled by the Fishery Management Research Program, Honolulu Laboratory.

n.mi. of the north side of Maui between November 1992 and January 1993 and, particularly, the catches of 15 tiger sharks during 13-17 November 1992 indicate that incidental tiger shark catches by the longline fishery can have significant local impact on the tiger shark population.

While information of the size of the tiger sharks caught is not reported, discussions with vessel captains reporting catches indicate the sizes of tiger sharks caught on the longline gear range from 5 to 17 feet.

The reported catches of 35 tiger sharks by the longline fishery over the past 2 years indicate that tiger sharks may be attracted to longlines either because of the bait, or to prey on fish caught by the longline. Thus, there may be significant links between the longline fishery and tiger shark populations. A nearshore longline fishery may provide forage to support a tiger shark population, but may also inflict some fishing mortality on the population. Thus, temporal and spatial trends in fishing effort of the pelagic longline fishery may have an impact on the tiger shark population and, ultimately, tiger shark and human interactions.

Literature Cited

Balazs, G. H. In press. Shark attacks in Hawaii. *In* L. Taylor (Editor), Sharks of Hawaii: Their biology and cultural significance, p. 90-124. Univ. Hawaii Press, Honolulu.

Randall, J. E. 1992. Review of the biology of the tiger shark (*Galeocerdo cuvier*). Aust. J. Mar. Freshwater Res. 43:21-31.

Tester, A. L. 1969. Cooperative shark research and control program, final report, 1967-69. Univ. Hawaii Press, Honolulu, 47 p.

Tricas, T. C., L. R. Taylor, and G. Naftel. 1981. Diel behavior of the tiger shark, *Galeocerdo cuvier*, at French Frigate Shoals, Hawaiian Islands. Copeia 1981:904-908.

Comparisons of Shark Catch Rates on Longlines Using Rope/Steel (Yankee) and Monofilament Gangions

STEVEN BRANSTETTER and JOHN A. MUSICK

Introduction

In 1973, the Virginia Institute of Marine Science (VIMS) began a depth-stratified longline sampling program to examine the distribution, abundance, and biology of sharks from the lower Chesapeake Bay to the edge of continental shelf along the U.S. mid-Atlantic coast. To maintain the integrity of the survey design, the program has used the same gear configuration since its inception: A modified "Yankee" or "New England" longline rig, so named because of wide-spread use in the New England swordfish fishery in the 1960's (Berkeley et al., 1981). The VIMS gear consists of a buoyed hard-laid nylon mainline from which hang gangions composed of hard-laid nylon rope with a steel leader.

In addition to monitoring the status of the shark populations of the Chesapeake Bight, the VIMS program has been a source of specimens for related research projects. During the course of the program, the catch per unit effort (CPUE) has declined approximately 75% (Musick et al., 1993). The large-coastal shark stock of the northwest Atlantic has been overfished for almost a decade (NMFS, 1993), and the declining CPUE of the VIMS survey can be at least partially attributed to this. Because the longline program fishes a set number of hooks at specific sites during each survey, the declining catch rate has meant that a substantially reduced number of individuals have been collected for research purposes. Proportional increases in effort to offset such a large reduction in CPUE were logistically prohibitive; therefore we sought a more efficient, ancillary method of capturing sharks to supplement the catches of the traditional survey.

During the 1970's, the commercial fishing industry replaced "Yankee" gangions with monofilament gangions because catch rates for swordfish and tuna were much higher using the latter gear (Berkeley et al., 1981). A side-benefit for this fishery was that the unwanted shark by-catch could escape by biting through the monofilament (Graham, 1987; Berkeley and Campos, 1988); "bite-offs" averaged about 5% of the hooks per set. Even so, shark catch rates increased, often exceeding the catch rate of the targeted species (Branstetter, 1986; Berkeley and Campos, 1988). Additionally, fishermen in the current commercial directed shark fishery have told us[1] that they prefer monofilament longline gear because it is more efficient. Based on this information, we added monofilament gangions to the standard longline rig as a way to increase catches without a substantial increase in effort. Herein, we compare catch rates between these two gear types fished simultaneously in the Chesapeake Bight region during 1991 and 1992.

Methods and Materials

Longlines were fished monthly from June through September at specific stations from the lower Chesapeake Bay to the edge of the continental shelf (200 m contour); additional localities were fished on occasion to provide supplemental data on species distribution and abundance (Fig. 1). For analysis, efforts were stratified by depth: 1) Lower Chesapeake Bay, 2) coastal (<10 m depth), 3) nearshore (10-20 m depth), 4) mid-shelf (20-100 m depth), and 5) offshore (>100 m depth).

The traditional VIMS longline rig consists of 6.4 mm (1/4-inch) tarred hard-laid nylon mainline anchored at both ends with 3-5 m gangions spaced about 20 m apart. Buoys are placed on the mainline at 20-gangion intervals.

The authors are with the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA 23062. This paper is VIMS contribution 1781. Mention of trade names or commercial firms or vessels in this paper does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—During the months of June through September in 1991 and 1992, 71 shark longlines were fished in the Chesapeake Bight region of the U.S. mid-Atlantic coast with a combination of rope/steel (Yankee) and monofilament gangions. A total of 288 sharks were taken on 3,666 monofilament gangions, and 352 sharks were caught on 6,975 Yankee gangions. Catch rates between gear types differed by depth strata, by month, and by species. Analyses were divided between efforts in the nursery ground of the sandbar shark, Carcharhinus plumbeus, *in Chesapeake Bay and efforts outside the Bay. Mean catch per unit effort (CPUE) ± SE, as sharks caught per 100 hooks fished, was significantly ($P<0.05$) lower for Yankee gangions. Mean CPUE's for sandbar sharks in the nursery ground were 20.6 ± 3.8 for Yankee gangions and 26.0 ± 3.0 for monofilament gangions, and mean CPUE's for all species combined outside the Bay were 3.7 ± 0.7 for Yankee gangions, and 6.9 ± 1.2 for monofilament gangions.*

[1]E. Sanders, Daytona, Fla., and H. West, Madeira Beach, Fla., 1991. Personal commun.

"Yankee" gangions consist of a heavy-duty quick-snap with 8/0 swivel, 2-3 m of 3 mm (1/8-inch) tarred hard-laid nylon line, an 8/0 swivel connecting 1-2 m of 1.6 mm (1/16-inch) 7X7 stainless steel wire, and a 9/0 hook. Hereafter, these gangions are referred to as "steel" gangions.

The monofilament gangions consist of the same quick-snaps and hooks, and are of similar length to the steel gangions. Two diameters, 1.6 mm (1/16-inch) and 2.4 mm (3/32-inch), of monofilament are used, but the breaking strength of both is 227 kg (500 pounds).

During this survey period, a "standard" longline consisted of 100 steel gangions set as a continuous unit with 50 monofilament gangions placed at one end of the line. The number of gangions for both gears varied on occasion due to gear loss during a survey or in an attempt to maximize production. To compare catch rates, a more statistically acceptable gear configuration would have been to alternate the gangion types at some interval, or to set them randomly along the line. However, gear comparison was not the primary purpose of the monofilament effort; it was meant to provide additional specimens for research purposes. It was more important to maintain the 100 steel gangion integrity of the longline for comparison with archival data; thus, the monofilament gear was set separately, but contiguously.

Longlines were fished for 3-4 hours duration. Based on sonar scans of longlines set in deep water, the catenary of the mainline reached depths exceeding 80 m; thus, for most coastal stations the majority of hooks were on or near the bottom specifically targeting semidemersal species. Hooks were baited with cut mackerel, *Scomber scombrus*, or whole menhaden, *Brevoortia tyrannus*; if both bait types were used on a set, they were used randomly on both gangion types. Bait pieces were 0.10-0.25 kg each in order not to exclude the capture of small fish.

Catch by species for each set was recorded according to gear type. Healthy sharks not needed for biological sampling were tagged with M-type dart tags supplied by the National Marine Fisheries Service and released after species, length, and sex were determined; lengths were estimated for those large sharks that could not be safely boarded. Sharks that broke the gangion or dislodged the hook after being brought alongside were counted as a catch and noted as a "lost" shark. Broken gangions and "bite-offs" retrieved during haul-back were not recorded as a lost shark, nor were records kept as to the numbers of broken gangions retrieved for either gear type.

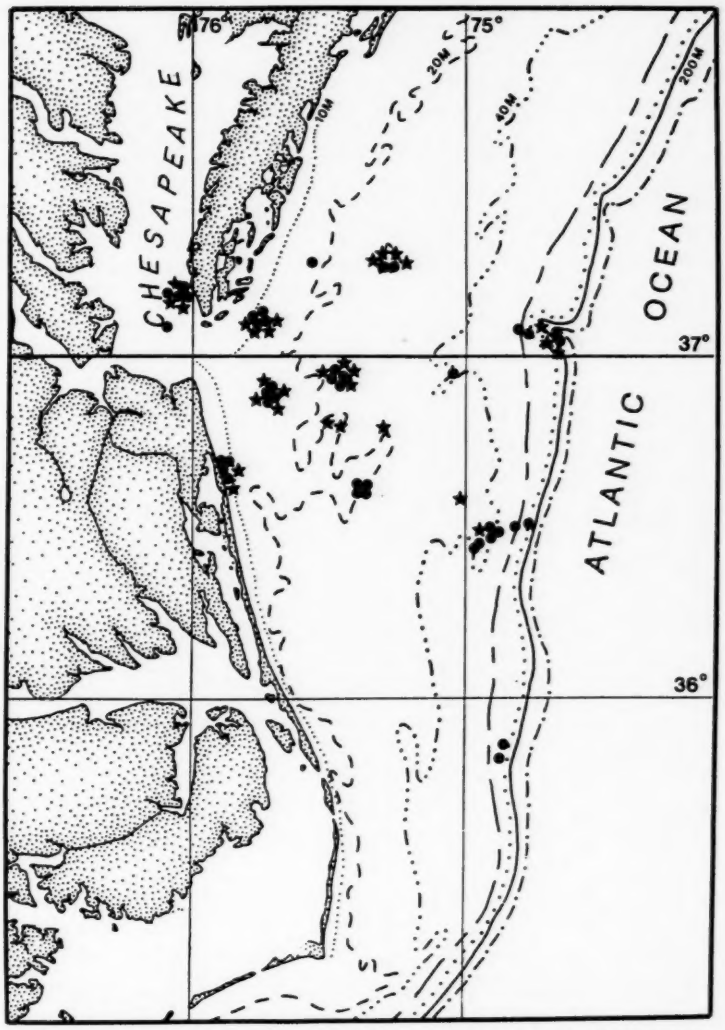

Figure 1.—Location of 71 longline sets in the Chesapeake Bight region that fished a combination of rope/steel and monofilament gangions during 1991 and 1992. Dots = 1991 sets, stars = 1992 sets.

Catch per unit of effort (CPUE) for each gear type per set was defined as sharks caught/100 hooks fished; a set that did not catch any sharks was not included in analyses. A mean CPUE over the 2-year period was calculated from the catch/set data, and a mean CPUE for each month and depth stratum was calculated from the catch/set data within each category. Calculations

of mean CPUE's for each species were restricted to catch/set data where a given species was taken on either or both gear types. This was done because certain species occur more commonly, or entirely, within a specific depth range or during a particular time of year. The absence of a particular species on a given longline set provides no information concerning gear efficiency, and may simply reflect the absence of that species from the area at that time. Species were categorized according to their general depth of capture (coastal vs. offshore), and analyses were restricted to those species represented by 10 or more individuals; other species were grouped in "miscellaneous coastal" and "miscellaneous offshore" categories (Table 1).

Differences ($P<0.05$) between mean CPUE's for each gear type for each category were compared with paired *t*-tests (Snedecor and Cochran, 1980). Longlining as a sampling method is notorious for its variable catch rates (Branstetter, 1981a, b; Berkeley and Campos, 1988), and large sample sizes that would reduce variability were not available in some categories. Thus, some graphically distinct differences were not statistically different. This was especially true for species analyses where the number of longline sets that caught a given species, and the number of individuals of a given species, were relatively few.

Table 1.—Species of sharks taken on longlines fishing rope/steel and monofilament gangions. Categories and species codes are those used in Figures 2 and 3.

Species codes	Scientific name	Common name
Coastal species		
CP	*Carcharhinus plumbeus*	Sandbar shark
RT	*Rhizoprionodon terraenovae*	Atlantic sharpnose shark
OT	*Odontaspis taurus*	Sand tiger
CO	*Carcharhinus obscurus*	Dusky shark
GC	*Galeocerdo cuvier*	Tiger shark
SL	*Sphyrna lewini*	Scalloped hammerhead
Misc. coastal		
CM	*Carcharhinus brevipinna*	Spinner shark
CL	*Carcharhinus limbatus*	Blacktip shark
CB	*Carcharhinus leucas*	Bull shark
MC	*Mustelus canis*	Smooth dogfish
SZ	*Sphyrna zygaena*	Smooth hammerhead
Offshore species		
IO	*Isurus oxyrinchus*	Shortfin mako
Misc. offshore		
CA	*Carcharhinus altimus*	Bignose shark
CF	*Carcharhinus falciformis*	Silky shark
PG	*Prionace glauca*	Blue shark
AS	*Alopias superciliosus*	Bigeye thresher

Results and Discussion

A total of 6,975 steel gangions and 3,666 monofilament gangions were fished on 71 longline sets over the sampling period (Table 2). Excluding zero-catch sets, the data base for analyses included 58 longline sets that caught 352 sharks of 13 species on 5725 steel gangions, and 288 sharks of 13 species on 3038 monofilament gangions.

Table 2.—Catch and effort data by depth and month for 71 VIMS longlines fished in 1991-92 with a combination of steel/rope (S) and monofilament (M) gangions. Numbers equal sharks caught/hooks fished for each combination-gear longline set. Thirteen zero-catch sets {listed in brackets} are not included in totals or analyses; instead of providing information on gear efficiency, they probably only indicate a lack of sharks in the area at that particular time.

		June		July		August		September		Total	
Area or depth	Year	S	M	S	M	S	M	S	M	S	M
Bay	1991	No effort		29/100	14/40	37/100	16/50	6/100	8/50		
						15/100	12/52	6/60	17/84		
										161/760	108/426
	1992	30/100	20/50	21/100	10/50	17/100	11/50	No effort		8 sets	
<10 m	1991	2/100	7/46	2/100	5/47	0/100	3/48	9/100	6/50		
										20/500	23/241
	1992	7/100	2/50	No effort		{0/100	0/50}	No effort		5 sets	
10-20 m	1991	5/100	3/47	{0/100	0/40}	3/100	5/50	8/100	11/50		
		0/100	3/46	16/100	6/40	9/95	14/50	13/100	8/50		
								2/100	1/50		
										129/1795	109/883
	1992	7/100	7/50	3/100	1/50	2/100	5/50	1/100	1/50	18 sets	
		3/100	1/50	22/100	14/50	11/100	6/50	21/100	20/50		
		2/100	3/50			1/100	0/50				
20-100 m	1991	{0/100	0/47}	{0/100	0/47}	{0/100	0/50}	1/100	1/53		
		1/92	5/50	1/100	3/47	0/100	1/50	{0/100	0/50}		
		2/100	1/47	{0/100	0/47}	8/163	2/100	8/100	14/100		
		2/100	3/47	0/70	1/47	1/50	0/50	0/100	1/100		
						4/95	0/50				
										32/1870	44/1091
	1992	1/100	0/50	{0/100	0/50}	{0/100	0/50}	0/100	2/50	19 sets	
		1/100	0/50	{0/100	0/50}	0/100	3/50	{0/100	0/50}		
								1/100	5/50		
								0/100	2/50		
								1/100	0/50		
>100 m	1991	{0/100	0/47}	2/100	0/47	{0/50	0/50}	1/100	0/50		
		1/100	0/50			0/100	1/50				
		2/100	3/50								
										10/800	4/397
	1992	1/100	0/50	1/100	0/50	No effort		2/100	0/50	8 sets	
Totals											
Sharks/hooks		67/1592	58/783	97/970	54/468	108/1503	79/800	80/1660	97/987	352/5725	288/3038
No. of sets		16		10		15		17		58 sets	

Species composition and relative abundance of each species were similar for each gear type (Fig. 2). Eleven species occurred on both gear types. Overall, sandbar sharks, *Carcharhinus plumbeus*, comprised about 55% of the total catch on both gear types. Chesapeake Bay is a major nursery ground in the western North Atlantic for the sandbar shark (Colvocoresses and Musick, 1980; Musick et al., 1993), and except for three individuals, all sharks caught in the Bay were juvenile sandbar sharks (Fig. 2, inset boxes). Catch rates for sandbar sharks in the Chesapeake Bay nursery were much higher than the catch rates for all species combined outside the Bay. For this reason, analyses that included sandbar sharks were divided between efforts inside and outside the Bay. Sandbar sharks outside the Bay were the second-most abundant species taken on longlines fished in this area. The Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, ranked second in overall abundance on both gear types; this small, schooling species was taken sporadically in large numbers at specific locations during each summer, and it was the most common species taken outside Chesapeake Bay. The remaining species occurred in low numbers throughout each summer.

Catch rates for five of the seven most common species were greater on monofilament gangions (Fig. 3). Overall, catch rates for the miscellaneous coastal species were higher on monofilament gangions, whereas catch rates for the miscellaneous offshore species were higher on steel gangions. Although mean CPUE's differed substantially between gears for several species, only the CPUE's for sandbar, Atlantic sharpnose, and sand tiger, *Odontaspis taurus*, sharks were statistically different ($P>0.10$ for all other species or species groups, probably reflective of the low sample sizes).

Catch rates were higher on monofilament gangions in all depth strata except outside the 100 m depth contour (Fig. 4a). Catch rates were significantly higher on monofilament gear in the Bay, nearshore (10-20 m), and mid-shelf (20-100 m) depth strata, and, although not statistically different, were 2.4 times higher on monofilament in the coastal (<10 m) depth stratum. Catch rates in offshore waters were slightly higher on steel gear. This was unexpected and in contrast to findings of Berkeley and

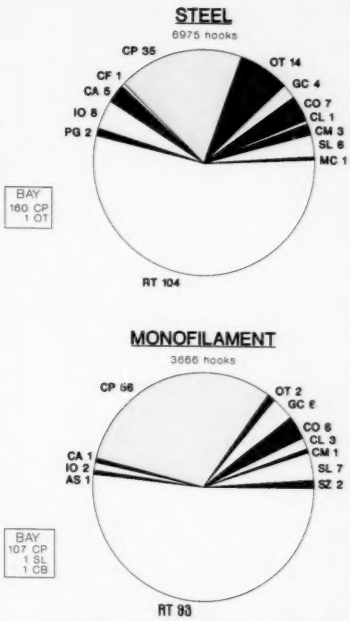

Figure 2.—Relative abundance of shark species taken on rope/steel and monofilament gangions on longline sets outside Chesapeake Bay. Catches for each gear type in the sandbar shark nursery ground inside Chesapeake Bay are noted in the boxes associated with each pie diagram. Species codes are listed in Table 1.

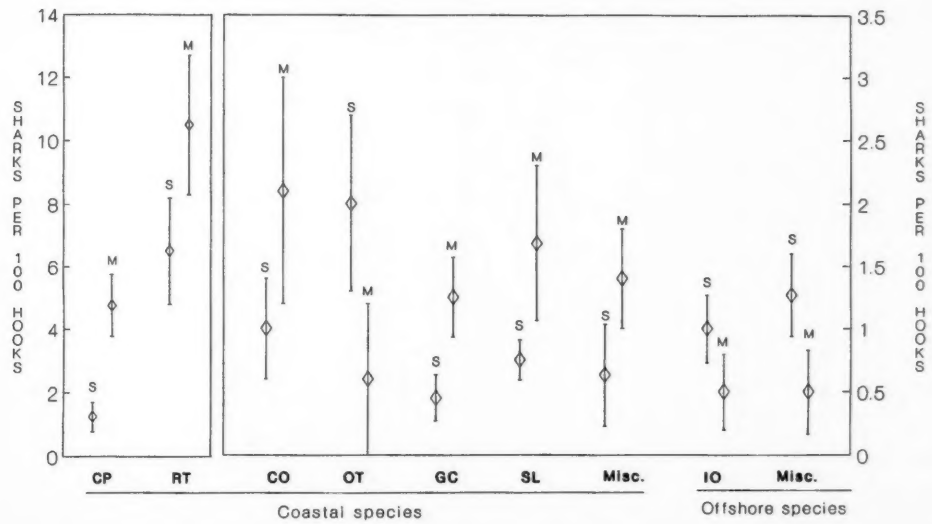

Figure 3.—Means ± one standard error for CPUE (sharks/100 hooks) on each gear type for the various shark species taken outside Chesapeake Bay. S = rope/steel gangions, M = monofilament. Species codes are listed in Table 1.

Campos (1988). They noted that shark catches in the offshore swordfish fishery were slightly higher on monofilament gangions (5.44 sharks/100 hooks) than on steel gangions (4.66 sharks/100 hooks), and that there was a mean loss of almost 5 hooks/100 monofilament gangions set. The species we took in the clearer waters of the offshore area are thought to be visually oriented predators; yet, although the monofilament is less visible in the water, when the "offshore species" listed in Figure 3 are pooled together, our catch rate on steel was more than 2:1 over that of monofilament.

The differences in CPUE between gear types was consistent throughout the sampling season, both inside (Fig. 4b) and outside the Bay (Fig. 4c). Although catch rates of juvenile sandbar sharks were more evenly distributed between gears in the Bay, mean CPUE's were always higher on monofilament gangions. Over the entire sampling period in the Bay the mean CPUE ± SE for monofilament gangions (26.0 ± 3.0) was significantly higher than that of steel gangions (20.6 ± 3.8). Mean CPUE's outside the Bay were higher on monofilament for every month and were significantly higher on monofilament during June and September. Over the survey period, mean CPUE's outside the Bay were significantly different between gears: Steel = 3.7 ± 0.7, monofilament = 6.9 ± 1.2.

Conclusions

The addition of monofilament gangions as an ancillary sampling effort of the VIMS shark longline program successfully increased the shark catch without a substantial increase in effort. The number of sharks collected for study nearly doubled, using only half again as many hooks. Over the 2-year period, catch rates were significantly higher on monofilament gangions. Monofilament has been a standard gear type for over a decade in the commercial fisheries, and our effort was initiated because of the success noted by commercial industry. Our results serve to highlight the widely divergent gear efficiencies. In the offshore swordfish fishery there is a general progres-

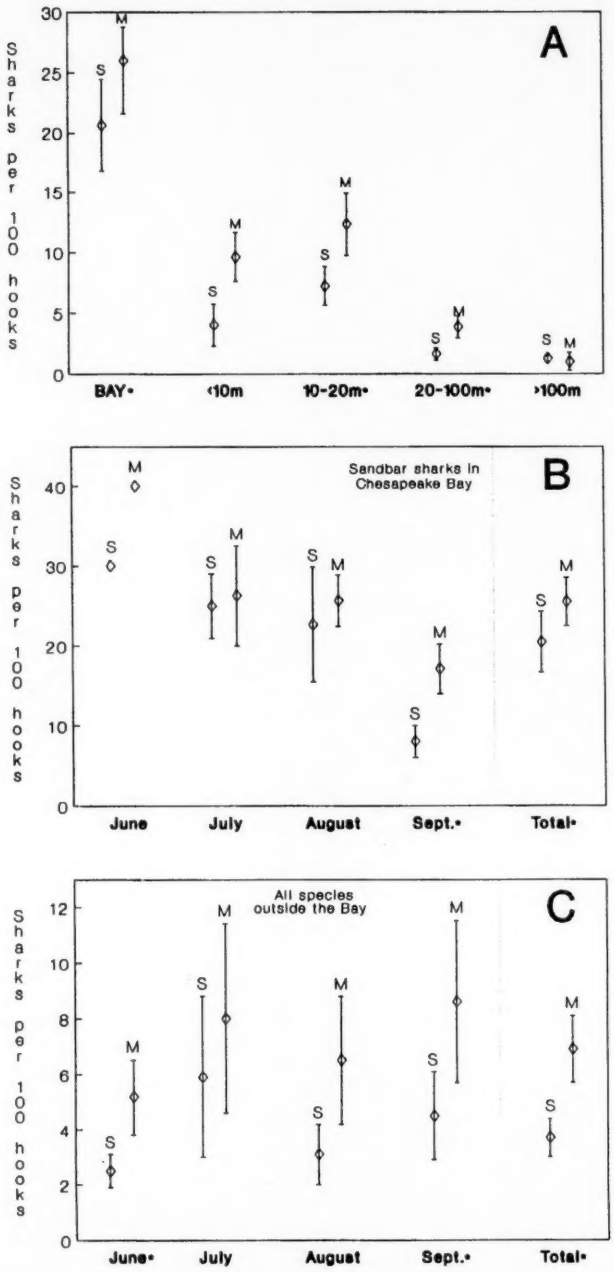

Figure 4.—Means ± one standard error for CPUE (sharks/100 hooks) on each gear type for designated depth strata and months. S = rope/steel catches, M = monofilament catches. Asterisks (*) indicate significant ($P<0.05$) differences between the means. A = catch rates by depth strata, B = catch rates of sandbar sharks in the Chespeake Bay nursery area, and C = catch rates for all species taken outside Chesapeake Bay.

sion in gear efficiency for both swordfish and pelagic sharks from "Yankee" gear to a monofilament/steel combination to monofilament (Berkeley et al., 1981; Berkeley and Campos, 1988), and our results of gear efficiency for coastal sharks are similarly divergent between gears.

Acknowledgments

Many people participated in the various survey cruises; their hard work is gratefully acknowledged. Capt. J. A. (Tony) Pennelo and crew of the MV *Anthony Anne* provided invaluable logistic support during each survey. J. A. Colvocoresses reviewed a draft of the manuscript, providing several suggestions that improved the quality of analyses and presentation of results. The longline survey is supported by "Wallop-Breaux" funds of the Federal Aid in Sport Fish Restoration Act, administered by the U.S. Fish and Wildlife Service, and distributed to VIMS through the Virginia Marine Resource Commission, project F97-R2.

Literature Cited

Berkeley, S. A., and W. L. Campos. 1988. Relative abundance and fishery potential of pelagic sharks along Florida's east coast. Mar. Fish. Rev. 50(1):9-16.

_____, E. W. Irby, Jr., and J. W. Jolly, Jr. 1981. Florida's commercial swordfish fishery: Longline gear and methods. Fla. Coop. Ext. Serv., Mar. Advis. Serv., Mar. Advis. Bull. 14, 23 p.

Branstetter, S. 1981a. Shark fishery potential for the northern Gulf of Mexico. Dauphin Isl. Sea Lab. (Ala.) Tech. Rep. 81-001, 21 p.

_____. 1981b. Biological notes on the sharks of the north-central Gulf of Mexico. Contrib. Mar. Sci. 24:13-34.

_____. 1986. Biological parameters of the sharks of the northwestern Gulf of Mexico in relation to their potential as a commercial fishery resource. Texas A&M Univ., Coll. Sta. Ph.D. dissert., 138 p.

Colvocoresses, J. A., and J. A. Musick. 1980. A preliminary evaluation of the potential for a shark fishery in Virginia. VIMS Spec. Sci. Rep., Appl. Mar. Sci., Ocean. Engr. 234, 39 p.

Graham, G. 1987. The development of Gulf coast shark fisheries: Synopsis. *In* S. Cook (editor), Sharks, an inquiry into biology, behavior, fisheries and use. Proceedings of the Conference, Portland, OR, 13-15 October 1985, p. 179-182. Oreg. State Univ. Ext. Serv., Corvallis, Publ. EM 8330.

Musick, J. A., S. Branstetter, and J. A. Colvocoresses. 1993. Trends in shark abundance from 1974-1991 for the Chesapeake Bight region of U.S. mid-Atlantic coast. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 115:1-18.

NMFS. 1993. Secretarial shark fishery management plan for the Atlantic Ocean. U.S. Dep. Commer., NOAA/NMFS Southeast Reg., St. Petersburg, Fla. var. pagin.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods (7th ed.). Iowa State Univ. Press, Ames, 507 p.

Inhibition of Protease Activity in Muscle Extracts and Surimi from Pacific Whiting, *Merluccius productus*, and Arrowtooth Flounder, *Atheresthes stomias*

ROY W. PORTER, BARBARA KOURY, and GEORGE KUDO

Introduction:

Recent increases in consumer demand for seafood have placed added pressure on traditional fishery stocks. Historically, Alaska pollock, *Theragra chalcogramma*, has been the major species of fish utilized for surimi processing, but it is being increasingly used for frozen fillets in various forms. This has resulted in decreased availability of pollock for surimi processing and has created interest in other stocks of fish suitable for surimi preparation.

A fish stock must satisfy several criteria to be suitable for surimi processing. These include relative abundance, mild flavor, and white flesh. In addition to Alaska pollock, there are two species of fish in the Pacific that meet these requirements. One is Pacific whiting, *Merluccius productus*, available on the Pacific coast from California to British Columbia. The second is arrowtooth flounder, *Atheresthes stomias*, which is found on the Pacific coast of the continental United States and Canada and in the Gulf of Alaska along the Aleutian chain and the Bering Sea.

Both Pacific whiting and arrowtooth flounder have been regarded as low-valued species due to a common problem of softening of the flesh during cooking (Patashnik et al., 1982; Dassow et al., 1970; Tsuyuki et al., 1982; Greene and Babbitt, 1990). This softening is the result of protease activity within the muscle tissue of both species. Kabata and Whitaker (1981) suggested that the softening of Pacific whiting during heating was associated with the presence of the myxosporean parasites *Kudoa paniformis* and *Kudoa thyrsitis*. Attempts to estimate the incidence of these parasites in this species produced varying results (Kabata and Whitaker, 1986; Kudo et al., 1987). It has been suggested that only the presence of *Kudoa paniformis* is correlated with soft texture in Pacific whiting (Tsuyuki et al., 1982; Kudo et al., 1987). Although the presence of myxosporean parasites has been reported in arrowtooth flounder, there does not appear to be a relationship between the level of incidence of parasites and autolysis of the flounder muscle. (Greene and Babbitt, 1990).

The enzyme(s) responsible for softening of the flesh of both species during cooking are located within the muscle fibers. It is therefore impossible to select and discard those fillets with high protease activity. As a result, attempts to utilize fillets in individual or block form have been relatively unsuccessful due to extreme variability in cooked texture. Consequently, these species have been marketed only sparingly in traditional forms.

Because surimi is produced in a finely comminuted form with cryoprotectants added prior to freezing, inhibitors can be added with the cryoprotectants during normal processing. Consequently, considerable interest exists for the utilization of Pacific whiting and arrowtooth flounder for surimi. This would serve to alleviate the pressure on the Alaska pollock resource which could be used for the more traditional fillet products.

Several studies have shown chemical inhibitors to be effective against the protease activity in Pacific whiting (Miller and Spinelli, 1982; Konagaya, 1984; Nagahisa et al., 1983). Although effective, these chemicals do not satisfy the necessary requirements as approved food additives. Natural sources of protease inhibitors exist and have varying degrees of specificity toward protease enzymes. Mammalian blood plasma contains inhibitors toward all classes of protease enzymes (Laskowski and Kato, 1980). Bovine plasma is currently used as an inhibitor in Pacific whiting surimi for export. Wasson et al. (1992b) have recently reported bovine plasma to be an effective inhibitor in arrowtooth flounder surimi. However, its acceptability as an ingredient for surimi remains questionable in the United States. Egg white also contains protease inhibitors shown to be effective in Pacific

The authors are with the Utilization Research Division, Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

ABSTRACT—Muscle extracts of Pacific whiting, Merluccius productus, *and arrowtooth flounder,* Atheresthes stomias, *were assayed for proteolytic activity using azocasein as a substrate. Pacific whiting extracts showed maximum activity at pH 5.0-5.2 and a temperature of 50°C, while arrowtooth flounder extracts had maximum activity at pH 5.5 and 55°C. Three sources of inhibitors (potatoes, egg white, beef plasma protein) were evaluated in vitro for inhibition of protease activity. All three were found to be effective inhibitors in crude muscle extracts. Further studies utilizing these inhibitors in surimi showed that potato was equivalent to both egg white and beef plasma protein in preserving the gel-forming characteristics of heated kamaboko in both species.*

whiting surimi (Haga et al., 1980; Nagahisa et al., 1983; Groninger et al., 1985; Chang-Lee et al., 1989; and Wasson et al., 1992b). The use of egg white, however, has not been widely accepted due to its high cost and off-flavors found at the levels required for inhibition. Potatoes are a rich source of protease inhibitors, and various preparations have shown activity in crude enzyme preparations from trout muscle (Kaiser and Belitz, 1973) and Pacific whiting muscle (Nagahisa et al., 1983; Porter et al., 1990).

There is a need for an inhibitor source that is effective, readily available, economical, and acceptable as a food ingredient. This study was conducted to compare the relative efficacy of a potato extract and potato powder with egg white and bovine plasma protein as inhibitors of crude protease preparations from Pacific whiting and arrowtooth flounder. These potential inhibitors were also tested in kamaboko prepared from both species. Kamaboko is a product made by mixing surimi with salt and extruding the resulting paste into a mold such as a casing and heating until gelation occurs. The integrity of the gel is severely impaired by the activity of protease enzymes during the heating step. Therefore, we compared the gel characteristics of cooked kamaboko prepared from surimi containing each of these inhibitors to determine the extent to which inhibition observed in the enzyme studies is reflected in improved gel properties of the kamaboko.

Materials and Methods

Preparation of Enzyme Extracts

Pacific whiting was obtained from Newport, Oreg., and arrowtooth flounder from the Goose Island area off the west coast of Canada. The fish were filleted, plate frozen, vacuum packed, and held at –29°C until used.

Samples of frozen fillets were thawed at room temperature. Then 300 g portions were diced and homogenized with 900 ml of extracting solution (1% NaCl and 0.2% NaN_3) in a Waring[1] blender. The homogenates were held overnight at 2°C, centrifuged at 10,400 *g* for 20 minutes, and the supernatant filtered through glass wool to remove fat. The supernatants were used as crude enzyme preparations.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Assay of Proteolytic Activity

Proteolytic activity was determined using azocasein as substrate (Barrett and Kirschke, 1981). The reaction mixture consisted of 2.0 ml of assay buffer, 0.2 ml of 6% azocasein (Sigma Chem. Co.), an aliquot of crude enzyme extract, and water to bring the total volume to 3.0 ml. All other reagents were combined prior to addition of substrate. Immediately upon substrate addition, the tubes were mixed on a Vortex mixer and placed in a 50°C water bath for 30 minutes. The reaction was terminated by adding 7.0 ml of ice-cold 5% trichloroacetic acid (TCA). After 30 minutes, the samples were filtered through Whatman #1 filter paper and A_{366} determined against a blank. Blanks were prepared by adding TCA prior to the enzyme.

The pH dependence of proteolytic activity was investigated over the range of pH 2.6 to pH 8.0 using two assay buffer systems. A 0.05M citrate-phosphate system was used from pH 2.6 to pH 5.8, while the pH 6.8 to pH 8.0 range was assayed using 0.05M sodium phosphate buffers. Incubation was for 30 minutes at 50° C.

The temperature-dependent activity was determined using a 0.05M citrate-phosphate buffer at pH 5.5. The assay buffer, water, and enzyme were combined and preincubated at the chosen temperature for 10 minutes prior to the addition of substrate, then incubated for an additional 30 minutes.

Inhibitors

Fresh Norgold potatoes were obtained from central Washington and placed in a 4°C cooler. They were either extracted within 2 days or chilled in ice-water, diced into 1/2-inch cubes, frozen and held at –29°C until needed.

The potato extract was prepared according to the method described by Melville and Ryan (1972) with modifications as described by Porter et al. (1990). Potato powder was prepared by freezing diced, fresh-peeled potatoes, then grinding the frozen dices through a meat grinder (3/16-inch die). The frozen ground potatoes were lyophilized and ball-milled to <100 mesh (U.S. screen) powder.

Dried egg white was obtained from ENER-G Foods, Inc., Seattle, Wash. Bovine plasma protein (AMP-600) was obtained from American Meat Protein Corp., Ames, Iowa.

Inhibition Studies

In the first experiment, water suspensions were made of potato extract (0.1%), egg white (3.0%), and bovine plasma protein (1.0%) and allowed to stand overnight at 2°C. The suspensions were centrifuged at 12100 *g* for 20 minutes and the clear supernatants used as inhibitors.

Assay mixtures consisted of 2.0 ml of 0.05M citrate-phosphate buffer (pH 5.5), a suitable aliquot of crude enzyme, inhibitor solution, and water to bring the volume to 2.8 ml. The samples were preincubated for 10 minutes at 50°C, then 0.2 ml 6% azocasein substrate was added. The samples were incubated for an additional 15 minutes and the reaction was stopped by the addition of 7.0 ml of 5% TCA. Controls were treated in the same manner with water replacing the inhibitor solution. The results were presented as a percentage of the activity of the controls (100%=no inhibitor).

A separate experiment was conducted using water suspensions of three concentrations of dried potato powder (2%, 4%, and 6%) along with potato extract (0.1%). These inhibitor solutions were prepared as described above and the assays conducted in the same manner.

Preparation of Surimi

Pacific whiting were caught off the west coast of the U.S.-Canadian border in early evening by mid-water trawl. They were immediately placed in champagne ice and transported to shore within 2-4 hours. Upon landing, the fish were transferred into iced bins and held overnight. The following morning they were filleted by machine (skin-on), packed in plastic bags, immersed in ice

and flown to Seattle. The fillets were transported to the NMFS pilot plant and processed into surimi starting at 24-30 hours after catching. The surimi was prepared as described by Scott et al. (1988). Temperatures were maintained at <10°C throughout transport and processing.

Arrowtooth flounder were caught near Kodiak, Alaska, in the evening, delivered to a local processing plant, and stored in ice overnight. The following morning they were hand-filleted, skinned by machine, packed in plastic bags, iced, and transferred to the NMFS pilot plant at Kodiak. The fillets were ground through a meat grinder with a $^3/_{16}$-inch plate and washed twice with ice water at a 3:1 (water:mince) ratio. Fat was skimmed off the top of the wash tank before each dewatering step. The dewatering was accomplished with a Model 4000 Brown Finisher equipped with a 1 mm screen and a gap of 3 mm between the paddles and screen at a speed of 500 rpm. After washing, the flesh was run through a Bibun Model 16 strainer to remove connective tissue and any remaining bone fragments and then through a Fukoku screw press (Model FKC, 1 mm screen, 2.5 rpm) to remove excess water. The presscake was blended with cryoprotectants (4% sugar, 4% sorbitol, 0.3% sodium tripolyphosphate) in a ribbon blender, placed in plastic bags, and frozen at –40°C. The surimi was shipped to Seattle, vacuum packaged, and stored at –29°C until analyzed.

Evaluation of Kamaboko

Frozen surimi in vacuum-packed cartons was tempered in running tap water to between –5°C and –3°C. The tempered surimi was sliced into $^1/_2$-inch slices and placed in a Stephan vertical cutter mixer (VCM-12-3/2 Model 12486) with an ice-water jacket. Inhibitor concentrations used were: Potato extract (0.06%, 0.1%, 0.2%, 0.3%); potato powder (3.0%, 4.0%, 5.0%); egg white (3.0%, 4.0%, 5.0%); bovine plasma (1.0%, 1.5%, 2.0%). To standardize the surimi concentration in all samples, the difference between the inhibitor concentration in a given test and 5.0% (i.e., the highest level used), was made up by addition of sucrose. Sucrose was chosen because it does not contribute to gel properties. In addition, 5% ice was added to each sample to make up for the added solids and 3% salt was added to solubilize the surimi. The same lot of surimi was used within each experiment for both species.

The surimi plus all additives were mixed under vacuum (<20 bar) and chopped until the temperature reached 9.8°C (6-8 minutes). The paste was stuffed into 3 cm diameter polyvinylidene chloride casings to make kamaboko sausages and heated for 40 minutes at 90°C in a water bath. The sausages were cooled in ice water for 10 minutes then reimmersed in the 90°C bath for 5 seconds to remove any wrinkles in the casings.

The kamaboko sausages were stored at ambient temperature overnight and evaluated the following day. Gel-strength was determined as described by Scott et al. (1988), except that a 5mm round probe was used in the present study. Each final value represents a mean of 20 determinations.

Results and Discussion

Enzyme preparations from both Pacific whiting and arrowtooth flounder showed similar activity against azocasein substrate with respect to temperature dependence (Fig. 1). Both exhibited measurable activity at 20°C which rose rapidly to an optimum of 50°C for Pacific whiting and 55°C for arrowtooth flounder. Activity was completely eliminated at 65°C for whiting and 70°C for the flounder.

Results of this study differ slightly from those of Greene and Babbitt (1990). They observed no activity below 40°C when measuring autolysis of arrowtooth flounder muscle, whereas in the current study, activity was found at temperatures as low as 20°C. Although activity was not measured at temperatures below 20°C, it is conceivable that the use of longer assay times may have demonstrated activity at lower temperatures.

Pacific whiting appeared to have a slightly lower pH optimum at pH 5.0-5.2 compared to pH 5.5 for arrowtooth flounder (Fig. 2). This observation is in agreement with the optimum pH observed for the autolysis of arrowtooth flounder muscle (Green and Babbitt, 1990). However, Wasson et al. (1992a) recently described a partially purified enzyme preparation from arrowtooth flounder that exhibited optimum activity at pH 3.0 using acid-denatured hemoglobin as substrate and pH 6.0-7.0 using casein. Using an enzyme prepared from Pacific whiting sarcoplasmic fluid, Erickson et al. (1983) observed optimum activity at pH 7.6 and 55°C using casein as a substrate. Differing methods of enzyme preparation and the use of different substrates for assaying activity are the most probable explanation for these variations and make a direct comparison of the results difficult.

During inhibition experiments using an enzyme extract from Pacific whit-

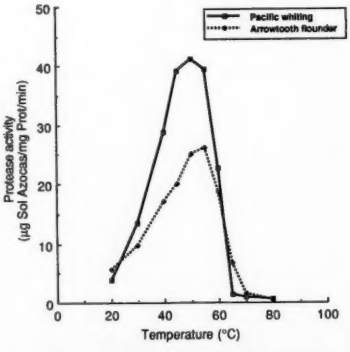

Figure 1.—Effect of temperature on protease activity of Pacific whiting and arrowtooth flounder.

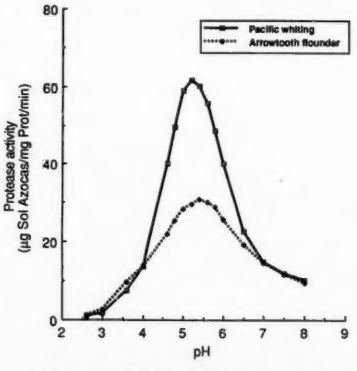

Figure 2.—Effect of pH on protease activity of Pacific whiting and arrowtooth flounder.

ing, the potato extract (0.1%) was a more effective inhibitor than either egg white (3.0%) or bovine plasma (1.0%) regardless of the amount of inhibitor solution added (Fig. 3). However, all were effective against this enzyme preparation, and, as expected, inhibition increased with increasing inhibitor concentration. For the enzyme preparation from Pacific whiting, the inhibition from potato extract leveled off at about 90%, whereas the addition of the same volume of egg white achieved about 70-75% inhibition and the bovine plasma around 80%. This clearly demonstrates that the inhibitors in potato are very effective as inhibitors of endoprotease activity in Pacific whiting extracts using azocasein as substrate.

Inhibition studies with enzyme extract from arrowtooth flounder showed potato extract (0.1%) and egg white (3.0%) leveled off at about 85% inhibition and bovine plasma (1.0%) reached ≈90% inhibition at the highest level of addition (Fig. 4). In these experiments the 400µl level of addition of potato extract solution (0.1%) was slightly less effective than bovine plasma (1.0%) at the same level. Nonetheless, it is still a very potent inhibitor of arrowtooth flounder enzyme extract. Further, these data confirmed the efficacy of both egg white and bovine plasma as inhibitors against the endoprotease activity of these enzyme preparations.

Concentrated potato extract solution (0.1%) was more effective in inhibiting enzyme activity in both species than solutions made from whole potato powder (Fig. 5, 6). As observed with egg white and bovine plasma, inhibition increased with increasing concentrations. These data illustrate that inhibitor activity is retained in dehydrated whole potato.

The dried forms of the various inhibitors were mixed with surimi to determine whether their addition provided sufficient inhibition in the surimi matrix to prevent breakdown of the kamaboko during heating. The gel characteristics of kamaboko made from Pacific whiting surimi with added dried inhibitors are presented in Table 1. As seen by the control data , the presence of an inhibitor was necessary to retain any gel-forming properties. The concentrated potato extract was effective at very low concentrations, peaking at 0.2%. Increasing the concentration from 0.2% to 0.3% did not achieve additional gel strength. Potato powder showed effectiveness at all levels added (3%, 4%, 5%). However, although the gel strength increased slightly at the higher concentrations, the deformation decreased slightly indicating that the kamaboko may simply become firmer and less elastic. This suggests that adding quantities above that adequate for enzyme inhibition is not necessary.

Egg white proved to be effective in stabilizing the gel-forming characteristics of surimi at the 3-5% level. This confirms the work of several other investigators (Haga et al., 1980; Nagahisa et al., 1983; Groninger et al., 1985; Chang-Lee et al., 1989) who have shown egg white to be an effective inhibitor in Pacific whiting surimi. Bovine plasma was also effective in the 1-2% range. Higher concentrations of bovine plasma were not used because of unfavorable contributions to flavor and color.

The same inhibitor preparations were added to arrowtooth flounder surimi to determine their effect on kamaboko gels formed during heating (Table 2). The results showed that the inhibition provided by each of the inhibitors was effective in preserving the gelation properties of kamaboko. The control sample containing no inhibitor had essentially no gel-forming properties. Again, as observed in the Pacific whiting experi-

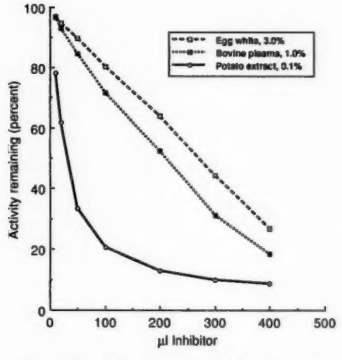

Figure 3.—Inhibition of Pacific whiting muscle enzyme by potato extract, egg white, and bovine plasma

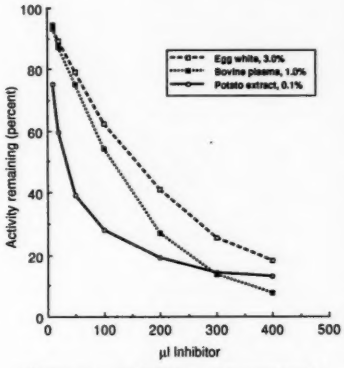

Figure 4.—Inhibition of arrowtooth flounder muscle enzyme by potato extract, egg white, and bovine plasma.

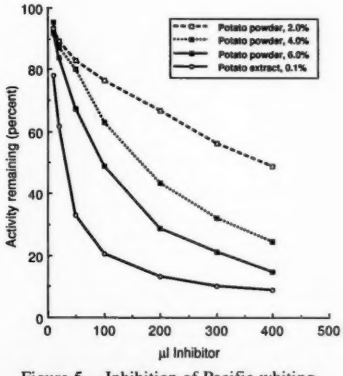

Figure 5.—Inhibition of Pacific whiting muscle enzyme by potato extract and potato powder.

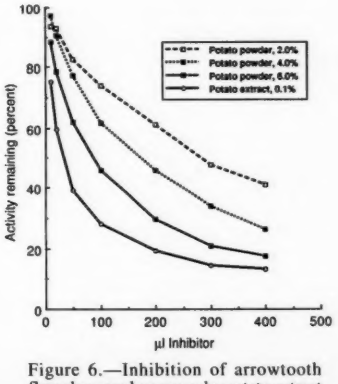

Figure 6.—Inhibition of arrowtooth flounder muscle enzyme by potato extract and potato powder.

Table 1.—Effect of various dried inhibitors upon the gel characteristics of kamaboko made from Pacific whiting surimi.

Inhibitor	Percent	Gel strength (g x cm) Avg.	(S.E.)	Load (g) Avg.	(S.E.)	Deformation (cm) Avg.	(S.E.)
Control		66	(3)	136	(40)	0.48	(0.01)
Potato extract	0.06	525	(24)	474	(12)	1.10	(0.02)
	0.10	531	(22)	463	(10)	1.14	(0.03)
	0.20	602	(16)	532	(8)	1.13	(0.02)
	0.30	571	(24)	517	(9)	1.10	(0.03)
Potato powder	3.0	511	(59)	487	(35)	1.05	(0.05)
	4.0	559	(79)	546	(48)	1.05	(0.06)
	5.0	589	(95)	599	(59)	0.98	(0.06)
Egg white	3.0	538	(117)	503	(64)	1.06	(0.09)
	4.0	566	(92)	547	(56)	1.03	(0.07)
	5.0	674	(107)	637	(64)	1.05	(0.07)
Bovine plasma	1.0	419	(61)	384	(34)	1.09	(0.07)
	1.5	502	(93)	445	(52)	1.12	(0.08)
	2.0	542	(98)	485	(53)	1.11	(0.07)

Table 2.—Effect of various dried inhibitors upon the gel characteristics of kamaboko made from arrowtooth flounder surimi.

Inhibitor	Percent	Gel strength (g x cm) Avg.	(S.E.)	Load (g) Avg.	(S.E.)	Deformation (cm) Avg.	(S.E.)
Control		38	(1)	90	(2)	0.41	(0.01)
Potato extract	0.06	231	(10)	241	(6)	0.95	(0.02)
	0.10	266	(12)	275	(7)	0.96	(0.02)
	0.20	250	(14)	259	(8)	0.95	(0.02)
	0.30	290	(8)	302	(5)	0.96	(0.01)
Potato powder	3.0	295	(11)	294	(7)	1.00	(0.06)
	4.0	329	(12)	354	(7)	1.02	(0.08)
	5.0	370	(15)	401	(10)	0.91	(0.07)
Egg white	3.0	229	(9)	275	(7)	0.83	(0.08)
	4.0	276	(14)	307	(10)	0.89	(0.09)
	5.0	336	(13)	369	(9)	0.91	(0.06)
Bovine plasma	1.0	212	(21)	215	(6)	0.98	(0.02)
	1.5	237	(19)	255	(5)	0.93	(0.02)
	2.0	331	(17)	329	(10)	0.99	(0.02)

ment, the concentrated potato extract was effective at very low concentrations in arrowtooth flounder whereas the potato powder was required at somewhat higher concentrations to be equally effective (3-5%). Egg white (3-5%) and bovine plasma (1-2%) were equally effective at the same concentrations used in Pacific whiting surimi, confirming the observations of Wasson et al. (1992b).

It should be noted that the absolute gel strength values for arrowtooth flounder were lower than those observed for the Pacific whiting. This may be due in large part to the fact that the flounder was washed only twice whereas the whiting mince received three washes during surimi preparation. Okada (1964) has shown that increasing the number of washes of arrowtooth flounder flesh had a positive effect on the gel-formation of cooked kamaboko.

By specifically inhibiting the protease activity, concentrated potato extract allows investigators to study the intrinsic gel-forming characteristics of Pacific whiting and arrowtooth flounder surimi. The contributions of significant quantities of additional ingredients that may affect gel-strength, e.g., starch (potato powder) and heat-coagulable protein (egg albumin and bovine plasma), are eliminated.

In conclusion, this study demonstrates that the inhibitors present in potato are potent inhibitors of the protease enzyme(s) extracted from both Pacific whiting and arrowtooth flounder muscle. This study confirms that egg white and bovine plasma protein also inhibit the protease enzyme(s) extracted from both species. Cooked kamaboko made from surimi without inhibitors had essentially no gel-strength (Pacific whiting, 66; arrowtooth flounder, 38). Surimi of both species required the addition of an inhibitor to preserve gelation properties during heating. Addition of either potato extract or potato powder preserved the gel forming properties of the muscle proteins. The effect of potato-derived inhibitors is comparable to that obtained by the addition of egg white and bovine plasma. This illustrates the efficacy of potato inhibitor either as an extract or in the form of potato powder as an alternative to egg white and bovine plasma for use in Pacific whiting and arrowtooth flounder surimi.

Literature Cited

Barrett, A. J. and H. Kirschke. 1981. Methods in enzymology, vol. 80. Proteolytic enzymes, pt. C. *In* L. Lorand (Editor), Acad. Press., N.Y. p. 542-543.

Chang-Lee, M. V., L. E. Lampila, and D. L. Crawford. 1990. Yield and composition of surimi from Pacific whiting (*Merluccius productus*) and the effect of various protein additives on gel strength. J. Food Sci. 55(1):83-86.

_____, R. Pacheco-Aguilar, D. L. Crawford, and L. E. Lampila. 1989. Proteolytic activity of surimi from Pacific whiting (*Merluccius productus*) and heat-set gel texture. J. Food Sci. 54(5):1116-1124.

Dassow, J. A., M. Patashnik, and B. J. Koury. 1970. Characteristics of Pacific hake, *Merluccius productus*, that affect its suitability for food. U.S. Dep. Inter., Fish Wildl. Serv., Circ. 332, p. 127-136.

Ericksen, M. C., D. T. Gordon, and A. F. Anglemeier. 1983. Proteolytic activity in the sarcoplasmic fluids of parasitized Pacific whiting (*Merluccius productus*) and unparasitized true cod (*Gadus macrocephalus*). J. Food. Sci. 48(4):1315-1319.

Greene, D. H., and J. K. Babbitt. 1990. Control of muscle softening and protease-parasite interaction in arrowtooth flounder, *Atheresthes stomias*. J. Food Sci. 55(2):579-580.

Groninger, H., G. Kudo, R. Porter, and R. Miller. 1985. Preparation and evaluation of surimi from Pacific whiting (*Merluccius productus*). *In* R. L. Martin and R. L. Collette (Editors), Proceedings of the International Symposium on Engineered Seafood Including Surimi, p.199-210. Seattle, Wash.

Haga, J., Shigeoka, and T. Yamauchi. 1980. Method for processing fish contaminated with sporozoa. U.S.Patent Off., Wash., D.C., Patent No. 4,207,354.

Kabata, Z., and D. J. Whitaker. 1981. Two species of *Kudoa* (Myxosporea: Multivalda) parasite in the flesh of *Merluccius productus* (Ayres, 1855) (Pices: Teleostei) in the Canadian Pacific. Can. J. Zool. 59:2085-2091.

_____ and _____. 1986. Distribution of two species of *Kudoa* (Myxozoa: Multivalvulida) in the offshore population of the Pacific hake, *Merluccius productus* (Ayres, 1855). Can. J. Zool. 64:2103-2110.

Kaiser, K.-P., and H.-D. Belitz. 1973. Specificity of potato isoinhibitors towards various proteolytic enzymes. Z. Lebensm. Unters.-Forsch. 151(1):18-22.

Konagaya, S. 1984. Studies on the jellied meat with special reference to that of yellowfin tuna. Chapter IV. Jellied meat in other species of fish. Section 2. Pacific hake. Bull. Tokai Reg. Fish. Res. Lab. 114 (Nov.):1-110.

Kudo, G., H. J. Barnett, and R. W. Nelson. 1987. Factors affecting cooked texture quality of

Pacific whiting, *Merluccius productus*, fillets with particular emphasis on the effects of infection by the myxosporeans *Kudoa paniformis* and *Kudoa thyrsitis*. Fish. Bull. 85(4):745-756.

Laskowski, M., Jr., and I. Kato. 1980. Protein inhibitors of proteinases. Ann. Rev. Biochem. 49:593-626.

Melville, J. C., and C. A. Ryan. 1972. Chymotrypsin inhibitor I from potato. J. Biol. Chem. 247(11):3445-3453.

Miller, R., and J. Spinelli. 1982. The effect of protease inhibitors on proteolysis in parasitized Pacific whiting, *Merluccius productus*, muscle. Fish. Bull. 80(2):281-286.

Nagahisa, E., S. Nishimuro, and T. Fujita. 1983. Kamaboko-forming ability of the jellied meat of Pacific hake. Bull. Jpn. Soc. Sci. Fish. 49(6):901-906.

Okada, M. 1964. Effect of washing on the jelly forming ability of fish meat. Bull. Jpn. Soc. Sci. Fish. 30(3):255-261.

Patashnik, M., H. S. Groninger, Jr., H. Barnett, G. Kudo, and B. Koury. 1982. Pacific whiting *Merluccius productus*: 1. Abnormal muscle texture caused by myxosporidian-induced proteolysis. Mar. Fish. Rev. 44(5):1-12.

Porter, R. W., B. J. Koury, and G. Kudo. 1990. Method for treating fish meat contaminated with sporozoa and potato product for improving heat gelation of fish muscle. U.S. Patent Off., Wash., D.C., Patent No. 4,935,192.

Scott, D. N., R. W. Porter, G. Kudo, R. Miller, and B. Koury. 1988. Effect of freezing and frozen storage of Alaska pollock on the chemical and gel forming properties of surimi. J. Food Sci. 53(2):353-358.

Tsuyuki, H., S. N. Williscroft, Z. Kabata, and D. J. Whitaker. 1982. The relationship between acid and neutral protease activities and the incidence of soft cooked texture in the muscle tissue of pacific hake, *Merluccius productus*, infected with *Kudoa paniformis* and/or *K. thyrsitis*, and held for various times under different pre-freeze chilled storage conditions. Fish. Aquat. Sci. Can. Tech. Rep. 1130.

Wasson, D. H., J. K. Babbitt, and J. S. French. 1992a. Characterization of a heat stable protease from arrowtooth flounder, *Atheresthes stomias*. J. Aquat. Food Prod. Technol. 1(3/4):167-182.

_____, K. D. Reppond, J. K. Babbitt, and J. S. French. 1992b. Effects of additives on proteolytic and functional properties of arrowtooth flounder surimi. J. Aquat. Food Prod. Technol. 1(3/4):147-165.

Charter and Party Boat Operators in the U.S. Gulf of Mexico: A Social Structure Perspective

DUANE A. GILL, ROBERT B. DITTON, and STEPHEN M. HOLLAND

Duane A. Gill is with the Department of Sociology, Anthropology, and Social Work and the Social Science Research Center, Mississippi State University, Mississippi State, MS 39762. Robert B. Ditton is with the Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843. Stephen M. Holland is with the Department of Recreation, Parks and Tourism, University of Florida, Gainesville, FL 32611. Views or opinions expressed or implied are those of the authors and do not necessarily reflect the position of the National Marine Fisheries Service, NOAA. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—To better address the charter and party boat fishery needs in the U.S. Gulf of Mexico, fishery managers must understand the linkages between the industry and other groups and organizations that affect its success. Gulf state charter and party boat operators were interviewed to ascertain the extent of their social network linkages, membership in community organizations, business community relationships, and linkages to information sources. Approximately one-third to one-half of the charter and party boat operators did not belong to local community organizations that could assist their business through tourism promotion or natural resource protection. Despite their limited integration in the community, the vast majority of operators gave and received referrals from other businesses. Of four major information sources, the National Weather Service and the County Marine Extension agents were rated highest and lowest, respectively, in mean importance to charter and party boat operators. Results suggest that business success can be enhanced by strengthening network ties between operators and local businesses, chambers of commerce, and tourism organizations. For this to occur, individual operators and charter/party boat organizations need to become more effective in representing industry interests. Informational linkages between industry and government agencies also need improvement.

Introduction

U.S. charter and party boat operators in states bordering the Gulf of Mexico (Gulf) occupy an ambiguous position within the marine fisheries community: They do not fit readily into either recreational or commercial fisheries. Marine anglers view charter and party boat operators as commercial fishermen because they earn their livelihood from fishing activities. On the other hand, commercial fishermen view them as a part of the recreational fishing community because their clientele consists of anglers. The picture is further complicated when some charter/party boat operators sell part of the recreational catch at local fish markets or engage in commercial fishing during the off season. Often, charter and party boat operators identify with neither group. This unsettled position is revealed in special regulations promulgated for the charter and party boat industry. In general, the allocation and bag limits for charter and party boat anglers falls under recreational allocation, but sometimes, special limits are promulgated specifically for the charter and party boat fishery (cf. 50 CFR 642.28). These regulations create uncertainty for operators who do not know how their clientele will respond. The rules also impact the traditional role for charter and party boat operators which as been to provide and enhance fishing opportunity.

To better understand the charter and party boat industry, fishery managers need a social structure perspective. This involves an understanding of linkages between the industry and other groups and organizations that affect its success. For example, the charter and party boat industry is tied to some extent to the larger tourism industry, government agencies that regulate and provide services, and customers. The charter/party boat industry is comprised of individual businesses which are linked to communities through associations with other businesses and organizations. By understanding these linkages, management agencies can better address industry needs as it reacts to changing fish stocks and regulatory policies.

One approach to understanding the social structure of this industry is to examine its social network linkages. Social networks refer to the "web of group affiliations" (Simmel, 1955) and represent the structure of relations among social groups (Wellman, 1983). Network analysis includes the type and number of relations between individuals or groups. Previous work suggests that these relationship patterns affect aspects of power, influence, and communication (Brass, 1948; Czepiel, 1974; Cook, 1977). Previously, network analysis has been used to understand communication patterns and strategies that influence community tourism development (Cobb, 1988).

This paper describes some of the social networks in the U.S. Gulf charter and party boat industry and provides a basis for further understanding and analysis of the industry. Specifically, this paper focuses on operators' demographic characteristics, memberships in community organizations, business community relationships, and linkages to information sources. No previous studies were identified regarding social networks in the Gulf charter and party boat industry or elsewhere. Previous literature on networks is used to understand and assess the social structure of this industry.

First, demographic descriptions provide insight to the characteristics of individual operators in the industry. Cobb (1988) proposed a relationship between demographic characteristics and centrality in business networks as a key to business success. A higher mean age may be problematic to the industry, however, as operators reduce their business activities or retire. As operators retire, the industry might decline due to high business turnover rates perpetuated by a large number of inexperienced operators (Ditton and Loomis, 1985; Ditton and Vize, 1987). This can act to reduce industry credibility (Holland, 1988). Also, the number of years as a captain is a direct measure of experience and indirectly indicates extent of opportunity for cultivating ties with clientele. Length of community residence and number of years operating from one's home port reflect opportunities to establish and maintain community ties and demonstrate business success. We would expect that operators who are older and have a longer tenure in the business and the port community to hold more central positions in business networks.

Organizational membership can promote business interests through interactions with community leaders and other business proprietors. Further, as Cobb (1988) has proposed, involvement in community organizations is correlated with influence and centrality in referral networks. Linkages to local chambers of commerce help to promote business and improve business practices. Memberships in marine fisheries conservation groups are an effort to help protect the resource base on which the industry depends.

Local communities attract new charter/party boat customers (and retain current clientele) with facilities and services such as hotels/motels; restaurants, service stations, bait shops, etc. (Roehl et al., 1989). Giving and receiving business referrals are a significant part of this network. Receiving referrals increases clientele whereas referrals to other local businesses is beneficial to the community and facilitates reciprocal relations between businesses (Cobb, 1988). Centrality in referral exchange networks leads to greater influence with networks (Boje and Whetten, 1981).

Centrality in communication networks has been found to enhance one's ability to control valued resources and influence favorable outcomes (Hinings et al., 1974; Brass, 1984). We would expect charter/party boat operators to require information on fishing conditions and regulations, business and tax regulations, technological innovations, marketing strategies, and weather conditions. Although local organizations such as the chamber of commerce are likely to provide some of this information, boat operators are likely to rely on government agencies to some extent for information and assistance.

Methods

Personal interviews were conducted with a random sample of operators. The sample included 50% of charter operators in Texas, Louisiana, Mississippi, and Alabama and 30% in Florida. The sample of party boat (also referred to as head boat) operators included all in Texas, Louisiana, Mississippi, and Alabama and 24% in Florida. Interviews in Florida and in the other Gulf coast states were conducted in 1988 and 1987, respectively.

The 19-page interview schedule included sections on operators' demographic characteristics, perceptions of ties to community businesses, organizational membership patterns, and informational linkages. Demographic information included age, gender, race, education, income, and marital status. In addition, data were collected on operators' years of service as captain, years of community residence, and the length of operation from their current home port. Operators were asked whether they were members of various organizations, including the local chamber of commerce and marine-oriented organizations (e.g., charter and party boat associations).

Ties to the local business community included the operator's receiving and giving business referrals and their perception of the local business community's understanding and appreciation of the economic contributions made by the charter and party boat industry. Data were based on a "yes-no" response to questions about these issues. Operators were also asked to identify marine-oriented publications they received. Further, they were asked to rate the importance of information received from the National Marine Fisheries Service (NMFS), National Weather Service (NWS), their state fish and wildlife agency, and local county/parish marine extension agent. These information sources were rated on a 5-point scale ranging from extremely unimportant (5) to extremely important (1). Additional information on the research methods can be found in Ditton et al. (1992) and Holland et al. (1992).

Results

Demographic Characteristics

Demographic data indicate that the average charter boat operator is a 45-year-old male, has more than 13 years of operating experience, has lived in the community for 20 years, and operated out of his home port for 12 years (Table 1).

The survey provides additional insight to charter boat fishery demographics. For example, three-fourths of the sample in Texas, Louisiana, Mississippi, and Alabama and about eight-tenths of the Florida sample operated

Table 1.—Demographic characteristics of charter and party boat operators in the U.S. Gulf of Mexico by state.

Operator characteristics	Florida	Alabama	Mississippi	Louisiana	Texas	Gulf
Charter boat operators						
Mean age	42.4	45.6	53.8	42.8	47.3	45.0
Mean years as captain	13.7	14.4	21.8	11.7	10.9	13.3
Mean years of community residence	19.3	28.8	32.8	22.1	14.4	20.0
Mean years operating out of home port	12.3	13.2	20.7	8.9	10.6	12.0

	Florida	Northern Gulf states (AL, MS, LA)	Texas	Gulf
Party boat operators				
Mean age	43.0	46.0	40.2	42.5
Mean years as captain	15.3	13.4	13.5	14.6
Mean years of community residence	20.1	29.0	22.1	21.9
Mean years operating out of home port	11.7	9.5	12.7	11.8

on a full-time basis (Ditton et al., 1988; Holland and Milon, 1989). Within the former sample, almost two-thirds of Alabama's charter operators were full-time compared to nine-tenths of Mississippi's charter operators. Almost one-fourth of the Florida charter sample was either a second, third, or fourth generation operator compared to about one-fifth of the sample in the remaining Gulf states. These figures indicate sufficient business demand to support most operators on a fulltime basis over time.

Demographic characteristics for party boat operators are similar to charter boat operators (Table 1). The average party boat operator is a 43-year-old male, has about 15 years of operating experience, has lived in his community 22 years, and has operated out of his home port for about 12 years.

There was a greater percentage of full-time operators in the party boat industry than the charter boat industry. All party boat operators in Texas were full-time and over nine-tenths of Florida operators and eight-tenths of operators from the northern Gulf states were full-time. Stability and longevity of the party boat fishery was demonstrated by the fact that over 40%, 25%, and 20% of Texas, Florida, and northern Gulf states party boat operators, respectively, were second or third generation operators (Ditton et al., 1988; Holland and Milon, 1989).

Organizational Membership Patterns

Charter boat operators were more likely to be members of marine-oriented organizations than chambers of commerce or other local groups (Table 2). About half of the Gulf operators belong to marine-oriented organizations. Membership was highest in Alabama and Florida and lowest in Mississippi and Texas. Operators in the latter two states reported local charter/party boat organizations were relatively inactive and ineffective in representing the industry. Reported benefits of membership in marine-oriented organizations included promotion and advertising support, fishing information, and support for improved recreational fishing.

Rates of membership in the local chamber of commerce were less than in marine-oriented organizations in all Gulf states except Mississippi. Half of Mississippi operators belonged to their chamber of commerce compared to one-third of all other charter boat operators in the Gulf. Members noted their chamber of commerce supported charter businesses through the distribution of brochures, giving referrals, and promotion of tourism.

Organizational membership patterns among party boat operators indicated the chamber of commerce is more popular than marine organizations and local organizations (Table 2). About half of all party boat operators belonged to their local chamber of commerce. Compared to three-fourths of Florida operators, only one-third of Texas operators were members of their local chamber of commerce. Operators who are members reported they received support in terms of promotion of their business and tourism in general.

Party boat operators' membership in marine-oriented organizations was more apparent in Florida than in the remaining Gulf states. As with charter operators, party boat operators in the northern Gulf states and Texas reported their local marine-oriented organizations are relatively inactive. Membership in other organizations was not frequent among party boat operators.

Business Community Ties

Gulfwide, half of the charter operators felt the local business community understood and appreciated the economic contributions of the charter/party boat industry (Table 3). However, most operators in Louisiana, Mississippi, and Alabama felt their economic contributions were not well understood by the local community. In business referrals, charter boat operators tended to give more than they received. The greatest disparity was in Florida and Alabama. Trends in these states indicate charter boat operators may be less integrated into the local business community, particularly with tourism and service businesses which have opportunities to make referrals.

Party boat operators appear to have a more favorable relationship with the local business community (Table 3). These businesses tended to be located in larger communities with a greater likelihood of better port facilities and a more extensive network of business services and referrals. About two-thirds of the operators in Florida and Texas felt the economic contributions of their industry were understood and appreciated by the local business community. In the northern Gulf states, however, none of the operators felt this way. Likewise, this pattern was reflected in the giving and receiving of referrals. All operators in Florida and Texas gave and received referrals, but only two of the five operators in the northern Gulf states reported giving and receiving referrals.

Informational Linkages

Two-thirds of the Gulf charter boat operators subscribed to one or more marine-oriented publications[1] (Table 4).

Table 2.—Community organization membership of charter and party boat operators in the U.S. Gulf of Mexico by state.

Operator and organization	Percent membership					
	Florida	Alabama	Mississippi	Louisiana	Texas	Gulf
Charter boat operators who:						
Belonged to a marine-oriented organization	56.6	63.6	37.5	42.1	38.3	51.9
Belonged to Chamber of Commerce	34.8	13.6	50.0	20.0	29.8	31.1
Belonged to other local organizations	12.8	13.6	37.5	35.0	22.2	17.4

	Percent membership			
	Florida	Northern Gulf states (AL, MS, LA)	Texas	Gulf
Party boat operators who:				
Belonged to a marine-oriented organization	60.0	20.0	16.7	40.5
Belonged to Chamber of Commerce	76.2	60.0	33.3	51.3
Belonged to other local organizations	25.0	20.0	8.3	18.9

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Saltwater Sportsman was the most commonly taken publication. Other popular publications were *Boats and Harbor, Yachting, National Fisherman,* and *Charter Industry Magazine*. In Florida, the *Florida Sportsman* was received by about one-fifth of the charter operators.

Data on informational linkages among Gulf party boat operators (Table 4) were similar to that of charter operators. About two-thirds of the party boat operators received a marine-oriented publication. *Saltwater Sportsman* and *Boats and Harbor* were the most commonly taken. Other publications mentioned frequently by party boat operators included *National Fisherman* and *Gulf Tide*.

Based on the mean importance rating of information sources, both charter and party boat operators value information from the NWS more than information from other sources. The majority of charter and party boat operators rated NWS data as either extremely important or important. In contrast, information from county/parish marine extension agents was rated as moderately or extremely unimportant by the majority of boat operators.

Operators were neutral regarding information from NMFS and state fish and wildlife agencies.

Discussion

Demographic differences in the region have implications for the charter/party boat industry. Whereas charter operators in Mississippi, for example, have more years of experience and longer tenure in their local communities, their retirement could impact service provision unless the next generation has prepared to remain in and contribute to the industry. The extent to which tourism opportunities in Mississippi may be affected if retiring captains are not replaced or replaced with less experienced operators has even greater implications. Alternately, with charter operators in Texas having the shortest tenure in their local communities, they will need to increase their community ties to enhance their business networks.

Overall, Gulf charter and party boat operators, as an industry, are not well positioned for business success from a social structure perspective. Since membership in organizations and networking capabilities are strong predictors of business success, we can begin to understand the highest business turnover in the for-hire marine operator business (Ditton and Loomis, 1985; Ditton and Vize, 1987). Since only one-half and one-third of charter and party boat operators, respectively, belonged to organizations or community business organizations they should not expect their economic contributions to be well appreciated locally. Beyond being good fishermen, operators need to join local community organizations to develop networks that can lead to business referrals and cooperative efforts. If, however, they entered this type of business for lifestyle reasons and for the independence of being one's own boss (Thursland et al., 1982), this expectation may not be realistic.

Operators need to consider working more closely with other businesses and local agencies and organizations to identify strategies to enhance their business and increase overall local tourism activity. Organizations such as chambers of commerce, tourism development councils, and local marine-oriented groups can provide a forum for improving support facilities and services, establishing a more effective referral program, and informing the business community of the economic contributions of local charter/party boat operations. Further, since many counties make local hotel-motel tax monies available for promotion of events and infrastructure development, operators need to be involved in these types or organizations if they are to access these funds. Few

Table 3.—Business community relationships of charter and party boat operators in the U.S. Gulf of Mexico by state.

	Percent membership					
Operator characteristics	Florida	Alabama	Mississippi	Louisiana	Texas	Gulf
Charter boat operators who:						
Felt that the business community understands economic contributions of the charter/party boat industry	52.1	40.9	37.5	35.0	56.5	50.0
Received business referrals	64.3	63.6	100.0	84.2	91.5	72.4
Gave business referrals	95.1	86.4	100.0	85.0	95.7	93.8

	Florida	Northern Gulf states (AL, MS, LA)	Texas	Gulf
Party boat operators who:				
Felt that the business community understands economic contributions of the charter/party boat industry	71.4	0.0	63.6	60.5
Received business referrals	100.0	40.0	100.0	92.1
Gave business referrals	100.0	40.0	100.0	92.1

Table 4.—Information linkages of charter and party boat operators in the U.S. Gulf of Mexico by state.

Information service	Florida	Alabama	Mississippi	Louisiana	Texas	Gulf
Charter boat operators						
Percent who subscribed to marine-oriented publications	62.9	63.6	87.5	60.0	76.6	66.3
Mean rating[1] of importance of information from:						
National Marine Fisheries Service	2.6	2.7	2.1	2.8	2.9	2.7
National Weather Service	1.8	2.3	1.4	1.8	1.6	1.8
State Fish and Wildlife Agency	3.1	2.3	3.6	2.5	2.3	2.9
County Marine Extension Service	3.9	3.8	3.7	3.2	3.4	3.7

	Florida	Northern Gulf states (AL, MS, LA)	Texas	Gulf
Party boat operators				
Percent who subscribed to marine-oriented publications	45.0	80.0	91.7	64.9
Mean rating[1] of importance of information from:				
National Marine Fisheries Service	2.3	3.0	2.5	2.6
National Weather Service	2.0	1.4	1.6	1.8
State Fish and Wildlife Agency	2.7	2.4	3.1	2.8
County Marine Extension Service	3.7	4.3	3.9	3.8

[1] Based on a 5-point scale: 1=extremely important; 2=moderately important; 3=neutral; 4=moderately unimportant; 5=extremely unimportant.

operators belong to these organizations, indicating they are not representing the needs of the industry (Ditton et al., 1988). Likewise, captains' associations in some areas are inactive, ineffective, or nonexistent. Operators should work to improve the ability of these organizations to better represent their interests.

If operators are to succeed in an increasingly regulated environment, they will need better access to information affecting their industry. With the exception of the NWS, it is not clear where operators get information in support of their business. Survey results indicate government agencies responsible for information transfer are not effective with this fishery sector. But using publications frequently read by operators, agencies could expand indirect communications and enable operators to anticipate and react to changing conditions that may impact their business, e.g., stock assessments, proposed regulatory changes, fuel prices, markets, and insurance conditions. The emergence of better information networks can help alleviate the adversarial feelings which often characterize operator reactions to fisheries policy making.

This paper has implications for future research and extension efforts. First, a variety of applied research projects are needed to provide support for this fishery. More research needs to be done to document the expenditures and economic impact of this industry at the community, regional, and statewide level (after Ditton et al., 1978). Also, research should provide a means for measuring and understanding business success and the health of the industry. Here, the goal should be to develop predictive models of business success which could identify areas where operators and local organizations can work to enhance tourism. Finally, research is needed to help operators develop new products (types of trips) that are appealing to customers and feasible in light of current regulatory regimes.

Second, the Gulf charter and party boat industry could benefit from a strengthened marine extension initiative aimed at improving business success. Marine extension programs could play a major role in providing information and technical assistance to the industry to help mitigate regulatory impacts. Educational workshops on the importance of customer satisfaction are needed. Also, as catch levels are reduced through regulations to enable stock recovery, extension personnel need to emphasize the importance of noncatch aspects of trips, e.g., crew hospitality, safety, marine education, sightseeing, and boat guest comforts.

As increased attention is paid to the social structure, social interaction, and business networks of charter and party boat fisheries, we should expect less business turnover, greater support for attracting tourists and coastal communities, more operator attention to and involvement in fisheries management issues, and greater community appreciation of charter/party boat services and their economic contribution. Ultimately, better service to consumers, a stronger industry, and more positive relationships with government agencies should result.

Acknowledgments

This research was supported by the Gulf of Mexico Marine Fisheries Initiative (MARFIN) administered by NMFS. Additional funding support was provided by the Texas Agricultural Experiment Station, the University of Florida Division of Sponsored Research, and the Mississippi Agricultural and Forestry Experiment Station (Project #MIS-4315). We appreciate the review comments of Ronald L. Schmied on an earlier version of this manuscript. We acknowledge the efforts of our coinvestigators John R. Stoll and J. Walter Milon, field interviewers, and project support staff. Most importantly, we acknowledge the charter and party boat operators who answered our questions and voluntarily provided us with the information essential to this paper.

Literature Cited

Boje, D. M., and D. A. Whetten. 1981. Effects of organizational strategies and contextual constraints on centrality and attributions of influence in interorganizational networks. Admin. Sci. Q. 26:378-395.

Brass, D. J. 1984. Being in the right place: A structural analysis of individual influence in an organization. Admin. Sci. Q. 29:518-539.

Cobb, M. 1988. Influence and exchange networks among tourism oriented businesses in four Michigan communities. Mich. State Univ., East Lansing. Ph.D. dissert. (unpubl).

Cook, K. S. 1977. Exchange and power in networks of interorganizational relations. Soc. Q. 18:62-82.

Czepiel, J. A. 1974. Word of mouth processes in the diffusion of a major technological innovation. J. Market Res. 11:172-180.

Ditton, R. B., and D. A. Gill. 1988. Developing strategies to enhance charter and headboat fishing operations in Texas, Louisiana, Mississippi and Alabama. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Final Rep. NMFS Contr. NA86WC-H-06107, 331 p.

_____ S. M. Holland, and D. A. Gill. 1992. The U.S. Gulf of Mexico party boat industry: Activity centers, species targeted, and fisheries management opinions. Mar. Fish. Rev. 54(2):15-20.

_____, R. N. Jarman, and S. A. Woods 1978. An analysis of the charter boat fishing industry on the Texas gulf coast. Mar. Fish. Rev. 40(8):1-7.

_____ and D. K. Loomis. 1985. Examining business turnover in the Texas charter boat fishing industry: 1975-1980. Mar. Fish. Rev. 47(1):43-47.

_____, J. R. Stoll, and D. A. Gill. 1988. The social structure and economics of the charter and party boat fishing fleets in Alabama, Mississippi. Louisiana and Texas. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Final Rep. NMFS Contr. 5617000. 323 p.

_____ and J. D. Vize. 1987. Business turnover in the Texas charter fishing industry: Revisited. Mar. Fish. Rev. 49(2):162-165.

Hinings, C. R., D. J. Hickson, J. M. Pennings, and R. E. Schneck. 1974. Structural conditions of interorganizational power. Admin. Sci. Q. 19:22-24.

Holland, S. M. 1988. Charter and headboat fishing as a sector of the tourism industry in Florida: Guidelines for greater integration and improved economic vitality. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Final Rep. NMFS Contr. NA86WC-H-06107, 179 p.

_____, R. B. Ditton, and D. A. Gill. 1992. The U.S. Gulf of Mexico charter boat industry: Activity centers, species targeted, and fisheries management opinions. Mar. Fish. Rev. 54(2):21-27.

_____ and J. W. Milon. 1989. The structure and economics of the charter and party boat fishing fleet of the Gulf coast of Florida. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Final Rep. NMFS Contr. NA87WC-H-06141, 278 p.

Roehl, W., R. B. Ditton, and D. R. Fesenmaier. 1989. An exploratory investigation of community-tourism industry ties. Ann. Tour. Res. 16:505-513.

Simmel, G. 1955. Conflict and the web of group-affiliations. Free Press, N.Y. [K. H. Wolff and R. Bendix, transl.], 195 p.

Thursland, M. E., M. A. Altobello, and N. K. Bender. 1982. The Connecticut charter boat fleet: Its characteristics, costs, and returns. Univ. Conn. Coop. Ext. Prog., Storrs., Rep. 82-23, 36 p.

Wellman, B. 1983. Network analysis: Some basic principles. *In* R. Collins (Editor), Sociological theory 1983, p. 155-200. Jossey-Bass, San Franc.

A Social and Economic Characterization of the U.S. Gulf of Mexico Recreational Shark Fishery

MARK R. FISHER and ROBERT B. DITTON

Introduction

To protect sharks from overfishing, the National Marine Fisheries Service (NMFS) proposed a Fishery Management Plan (FMP) for Sharks in the Atlantic Ocean[1]. The FMP was developed in light of several important issues: 1) Development of new shark fisheries in the 1980's that led to harvest levels exceeding maximum sustainable yield for large coastal sharks (Parrack, 1990), 2) foreign demand for shark fins that led to the controversial practice of "finning," 3) a general lack of management of shark fishing, and 4) the 1991 amendments to the Magnuson Fishery Conservation and Management Act (MFCMA) (16 USC 1801 et seq.) that gave the Secretary of Commerce authority over highly migratory species including oceanic sharks. In addition to placing 39 species of sharks in U.S. waters under Federal management, the proposed FMP[1] included the following management measures among others: 1) Reduced commercial harvest quotas for large coastal and pelagic sharks until stock abundance is increased, 2) a bag limit of four sharks/boat/trip for the combined large coastal and pelagic species groups and a daily bag limit of five small coastal sharks/person for the recreational fishery, 3) sharks taken beyond commercial quota or recreational bag limits must be released uninjured, 4) a ban on finning, and 5) institution of permit requirements and data reporting systems.

In their study of shark fishing club members, Graefe and Ditton (1976) reported that "there was little literature on shark fishing participation, less on participants, and none to explain shark fishing motivations." No work on shark anglers has emerged since then. From their paper, we would expect shark anglers to be highly motivated by the challenge or sport of the shark fishing experience. In particular, we would expect them to place high importance on the experience of the catch, i.e., the fight put up by the fish, but not on keeping and eating their catch. Likewise, we would expect them to be more avid than the general population of marine anglers.

If, as Graefe (1980) and Ditton et al. (1992) indicate, level of fishing frequency is a surrogate measure for recreation specialization, we would expect shark anglers to exhibit higher levels of self-reported skill, greater resource dependency, higher levels of expenditure associated with participation, more years of previous experience, and greater appreciation for catch and noncatch aspects of the fishing experience. Specialization is defined as "a continuum of behavior from the general to the particular reflected by equipment and skills used in the sport and activity/setting preferences" (Bryan, 1977). At one end of the continuum is the least specialized group of anglers with the most specialized group at the other. We would expect to find the shark fishery heavily skewed toward the most specialized group.

Currently, managers have little understanding of the effects of new regulations on shark anglers. As constraints are imposed on the shark fishery, anglers have alternatives. They may: 1) Adapt to bag limits and subsequent catch and release requirements for shark fishing, 2) enter a substitute fishery with fewer constraints, 3) continue to fish at

Mark R. Fisher and Robert B. Ditton are with the Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843. Mark Fisher's present address is Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, TX 78744. Views or opinions expressed or implied are those of the authors and do not necessarily represent the positions of the National Marine Fisheries Service, NOAA.

ABSTRACT—A mail survey of tournament shark anglers and party boat shark anglers was completed to examine their fishing activity, attitudes, trip expenditures, and consumer surplus. A sample of 700 shark anglers was selected from tournaments in the Gulf of Mexico during 1990, and a sample of party boat shark anglers was drawn from Port Aransas, Tex., party boat anglers during the summer of 1991. A response rate of 58% (excluding nondeliverables) was obtained from tournament anglers. The sample of party boat shark anglers was too small to provide useful results. Tournament shark anglers reported fishing an average of 58 days per year and targeted sharks and other large marine species. Tournaments occupy a small portion of their fishing effort. If this group of anglers were not able to fish for sharks, one-third indicated no other species would be an acceptable substitute, while others were willing to substitute other large marine species. Shark trip expenditures averaged $197 per trip with a consumer surplus of $111 per trip. Based on MRFSS estimates of the number of shark fishing trips, we estimate a total of $43,355,000 was spent by shark anglers in the Gulf of Mexico with a consumer surplus of $23,865,000 for a total gross value of the shark fishery of $66,220,000. MRFSS estimates of the number of sharks landed indicate an equivalent use value of $183 per shark.

[1]Fishery Management Plan for Sharks of the Atlantic Ocean. 1992. National Marine Fisheries Service, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

current levels for other fresh and saltwater species they target but make no effort to seek substitutes for shark fishing, or 4) stop all fishing entirely.

There are implications for management if anglers select substitutes that exacerbate constraints on other scarce resources. If we define substitutability as the extent to which one species can effectively replace another in terms of its ability to produce particular social benefits, i.e., recreation satisfaction (after Hendee and Burdge, 1974), then species perceived as meeting these criteria are considered substitutable. Whereas individuals participate in recreation experiences to fulfill specific needs, they seek alternatives which provide similar benefits when their initial activities are constrained (Vaske, 1980). While it is not necessary for substitutes to share similar biological characteristics, we would expect substitutes for shark fishing to have similar experience attributes and access costs (Shelby and Vaske, 1991).

While the proposed Shark FMP[1] contains information on commercial fishery landings and ex-vessel prices, a lack of data precluded calculation of the economic value of the recreational fishery. Valuation of recreational fisheries is difficult because sport fishing is not a marketed good. The absence of a market precludes the opportunity to directly observe the value anglers place on a fishery resource and its use. Angler expenditures, which are essential for understanding local and regional economic impacts, i.e., jobs, income, and tax receipts, are generally recognized as not being a valid measure of a fishing trip's true economic value (Huppert, 1983). A shark fishing trip has much greater social value than the cost associated with participation; anglers are willing to pay more for the use of the resources than the actual amount they pay for market goods and services. Measures of willingness to pay in excess of trip expenditures (Huppert, 1983) can be used to estimate the value of these additional benefits (consumer surplus) to anglers. Consumer surplus is the difference between price of a good (i.e., a shark fishing trip) and the gross use value of the trip (Bell et al., 1982). This is an important concept because it represents an increase in the welfare of the nation as a result of the opportunity to fish for sharks.

The proposed FMP[1] recognized the general lack of social and economic information on recreational fisheries. While data on recreational landings were estimated by the Marine Recreational Fishery Statistics Survey (MRFSS) (NMFS, 1991), no data were included on shark anglers and their fishing activity. Consequently, we completed a mail survey of shark anglers in the U.S. Gulf of Mexico. This research had three objectives: 1) To profile shark anglers according to their social and economic characteristics, fishing activity, attitudes, trip expenditures, and consumer surplus, 2) to estimate total trip expenditures and consumer surplus for shark anglers in the U.S. Gulf of Mexico region, and 3) to discuss the implications of results for proposed management measures. This information is prerequisite to increasing the benefits from shark resources, one of the stated objectives of the proposed Shark FMP[1].

Methods

Since no special license provides a sampling frame for shark anglers, we sought an alternative means of accessing this angler group. We sampled from a list of anglers who had participated in shark tournaments along the Gulf of Mexico during 1990 and those who had participated in a party boat fishery based in Port Aransas, Tex., during the summer of 1991. Party boats in Port Aransas were reported to account for most of the total Gulf party boat shark landings by weight[1]. These proxy angler groups were identifiable and provided a cost effective means of obtaining information from shark anglers. We recognized from the outset these were segments of the recreational shark fishery and evaluated results in light of other data on shark anglers and other groups of anglers.

Port Aransas Party Boat Fishery

Our original sampling plan was to select 20 days at random during the peak use season and conduct personal interviews of all shark anglers on party boats operated from Dolphin Docks[2] in Port Aransas. One of their boats was the *Shark Hunter*. We identified shark anglers as those who 1) said they were specifically targeting sharks that day and 2) had ≥1 year of previous shark fishing experience. Since we intercepted few anglers who met our criteria as shark anglers during our first sampling period, we abandoned the plan. As an alternative, we sampled every day and intercepted party boat anglers at the same party boat operation before they departed. From 1 July to 2 September 1991, we collected names and addresses from those who met the criteria as shark anglers for follow-up contact with a mail survey. The alternative sampling plan yielded 31 shark anglers, 19 of whom responded to the mail survey. This sample size was too small to provide useful results. Based on the results of daily intercepts, the original plan would have yielded only five anglers who indicated they were targeting sharks.

Tournament Shark Anglers

We identified 18 shark tournaments held in the Gulf of Mexico during 1990; officials from ten tournaments agreed to provide names and addresses of participants. To determine the threshold level of willingness to pay (P=0.5) with an accuracy of ±5% at the 95% level of confidence, a sample of 400 anglers is needed (Cochran, 1977). However, based on our previous experience with mailed surveys, we anticipated a response rate of about 60%. Therefore, we selected a systematic random sample of 700 shark anglers in order to receive 400 completed surveys.

A 10-page questionnaire was developed to collect information from anglers. First, anglers were asked about their fishing experience: Number of years fishing, number of years fishing for sharks, number of days fishing in the previous 12 months by setting, and an evaluation of their fishing ability compared with other anglers. Second, they were asked to identify their top three target species and to indicate

[2] Mention of trade names or commercial firms or facilities does not imply endorsement by the National Marine Fisheries Service, NOAA.

whether any one species commanded most of their effort. Third, anglers were asked a series of questions about their orientation toward catching fish. Anglers were asked to indicate the extent to which they agreed with each attitudinal statement on a Likert-type scale developed by Graefe (1980) to understand four subdimensions of consumption: Number of fish caught, type of fish caught, disposition of catch, and general orientation towards catching "something." Fourth, anglers were asked to indicate the importance of 17 motive statements or reasons for fishing using a Likert-type scale. Eleven were drawn from previous work by Driver[3]. Six motive statements dealt with experience elements associated only with sport fishing (activity-specific). Fifth, we asked anglers a series of questions about their participation in the shark fishery: Number of shark tournaments fished in the previous 12 months, location of shark fishing, most sharks kept/caught per day, gear size, and other fish commonly caught while shark fishing. Sixth, anglers were asked to indicate which species groups they would be willing to substitute if they were unable to fish for shark and, if not, to choose among selected reasons why. Finally, we asked anglers to report how much they spent for each of 11 expense items on their most recent shark fishing trip.

We used a close-ended contingent valuation (CV) question to ascertain the amount anglers were willing to pay for an increase in the cost of a shark fishing trip (Bishop and Heberlein, 1979). Each angler was presented with one random offer from ten bid values which ranged from $20 to $200 in increments of $20. Consumer surplus was evaluated using logistic regression. Logistic regression is appropriate when the dependent variable is a binary indicator variable (e.g., "yes" or "no"), and can be used to determine the probability of a "yes" response and thus the threshold level (P[yes]=P[no]=0.5) of an angler's willingness to pay (Agresti, 1990). Angler characteristics expected to affect willingness to pay included 1) annual number of shark fishing trips, 2) years of shark fishing experience, 3) expenditures per shark trip, and 4) annual household income. Using an open-ended format, anglers were also asked how much more they were willing to pay rather than stop fishing for sharks.

A total of 342 individuals responded to the mail survey for an overall response rate of 58% (when nondeliverables were excluded). Response rates varied from 73% in Texas to 55% in Florida. Mailings were initiated on 9 April 1991 following the procedures of Dillman (1978). A reminder postcard was mailed on 15 April, with second and third mailings on 30 April and 28 May, respectively.

A telephone survey of nonrespondents was completed to identify characteristics of nonrespondents for comparison with respondents. This was done to test the assumption the two groups were alike in order to check for nonresponse bias in the survey results (Bethlehem and Kersten, 1985). Questions were used regarding years of saltwater experience, species preference, years of shark fishing experience, and annual fishing frequency. Telephone calling resulted in 34 completed surveys from a sample of 40 nonrespondents. Using the Mann-Whitney U or chi-square test, as appropriate, we found significant differences between respondents and nonrespondents at the 0.05 level of significance for years of experience and annual fishing frequency. Respondents had more years of fishing experience and a higher annual frequency of fishing. Weighting procedures were implemented to reduce the effect of nonresponse (Kalton, 1983). Respondents were stratified by tournament and weighted by the inverse of the response rate within each tournament. Response rates by tournament varied from 39% to 94%.

Results

Port Aransas Party Boat Fishery

It would be unwise to make specific inferences about a population from only 19 respondents. Confidence intervals constructed about parameters were too wide to allow precise conclusions from the data.

Tournament Shark Angler Characteristics

Tournament shark anglers were 38 years of age on average and male (95%). Anglers reported fishing an average of 58 days during the previous 12 months, with 75% fishing at least 20 days. Days fishing in freshwater accounted for 9 days of the overall mean, with 25% fishing >6 days. Days fishing in saltwater from a boat and from shore averaged 38 and 12 days, respectively, indicating these anglers spent most of their time fishing in saltwater from a boat. About 42% rated themselves as "more skilled" than other anglers. Almost 91% rated themselves as "equally or more skilled" with the remainder "less skilled."

Sharks were the most preferred species by 25% of the respondents. Grouper was second most preferred (22%), followed by snook (16%). Less than 5% listed offshore pelagic species, with the remainder reporting inshore or coastal pelagic species. About 37% indicated they devoted most of their effort to one species. Of this group, shark was targeted by 30%, grouper 30%, and snook 12%.

Eleven motivational items were rated very to extremely important by most respondents (Table 1). Only three of these items were specific to saltwater fishing ("For the challenge or sport," "To be close to the sea," and "For the experience of the catch"). The two motive items that were most often rated as not at all important were "To obtain a trophy fish" and "To win a trophy or prize."

About 60% of the respondents agreed with the statement "I would rather catch one or two big fish than ten smaller fish" and 64% agreed with "I usually eat the fish I catch" (Table 2). Most agreed with the statements "I'm just as happy if I release the fish I catch," "a fishing trip can be successful if no fish are caught," "the bigger fish I catch, the better the fishing trip," and "the more fish I catch, the happier I am."

[3]Driver, B. 1977. Item pool for scales designed to quantify the psychological outcomes desired and expected from recreation participation. U.S. Dep. Agric., For. Serv., Rocky Mountain For. Range Exper. Sta., Fort Collins, Colo. Unpubl. rep.

Participation in the Shark Fishery

Anglers reported an average of 9 years experience fishing for sharks. Compared to the mean for saltwater fishing experience ($\bar{x}$=19 years), most probably began fishing for sharks after several years of saltwater experience. In the previous 12 months, this group of anglers participated in an average of two saltwater fishing tournaments with only one being a shark fishing tournament. This is probably due to the relatively low number of shark tournaments in the Gulf and their wide geographic dispersion.

Respondents reported they usually fish for sharks from shore (6%), in bays from a boat (12%), or in the Gulf from a boat ≤10 miles from shore (48%), with the remainder fishing ≥10 miles from shore. When asked to list the most sharks they caught in one day and the most kept in one day during the past 12 months, anglers reported an average of 4 sharks caught and 1 shark kept. About 75% reported at least 5 sharks caught in one day, and 75% reported at least 2 sharks kept in one day. This agrees with the finding that most shark anglers release the fish they catch (Table 2). Heavy tackle is favored by this group of anglers for shark fishing, as most listed hook sizes between 6/0 and 12/0 and line test between 50 and 80 pounds for a typical shark fishing trip. Other species of fish commonly caught while fishing for sharks included grouper (26%), tarpon (20%), sea catfish (18%), stingrays (14%), cobia (14%), snapper (8%), and bonita (5%). A total of 50 fish species were listed as bycatch, but no other species were mentioned by >5% of the respondents.

If this group of anglers were not able to fish for sharks, 32% indicated no other species would be an acceptable substitute. Seatrout/red drum, flounder, and pompano/permit were deemed unacceptable substitutes for sharks by most anglers, with king mackerel/dolphin/cobia listed as the most acceptable substitutes (Table 3). This agrees with the finding that most of this angler group prefers to catch big fish (Table 2) and would probably substitute other large fish species for shark. Billfish were unacceptable substitutes because this group of anglers had no access to that fishery (too expensive, too far offshore, etc.) (Table 4). Seatrout/red drum, flounder, and pompano/permit were unacceptable because they were perceived as not challenging enough.

On their most recent fishing trip for sharks, anglers reported an average expenditure of $197 (excluding tournament fees) (Table 5). The trip averaged 1.8 days in length, with an average expenditure of $109/day. Boat operation (fuel, oil, etc.) was the largest individual expense category, followed by food, drinks, ice, and bait and tackle (Table 5). When combined, these items accounted for 67% of total expenditures.

Table 6 reports the results of the logistic regression model of willingness to pay responses and consumer surplus estimates. Annual number of trips and household income were not statistically significant (P>0.10) and were not included in the final model. These two variables were not significant because the sample was homogeneous with respect to income and number of trips. The parameter estimates indicate the probability of a "yes" response decreases as the bid value increases and increases as years of shark fishing experience and total trip expenditures increase. When they were asked the open-ended question about the highest additional trip costs they would pay rather than stop fishing for sharks, the mean response was $105, indicating good agreement with the logit model.

Results from the most recent MRFSS (NMFS, 1991) indicate 1.13% of all intercepted anglers in the Gulf of Mexico were fishing primarily for sharks in 1989. During the same time, an estimated total of 19,064,000 fishing trips were taken in the Gulf, sug-

Table 1.—Distribution of anglers by the importance they attribute to various reasons why people fish in saltwater ranked by mean score.

Statement	Percent by category[1] 1	2	3	4	5	n	Mean
For the experience of the catch	2.3	1.4	15.5	35.6	45.3	339	4.2
For relaxation	2.5	3.5	13.7	35.0	45.4	337	4.2
To experience adventure and excitement	2.3	4.7	16.5	37.5	39.1	339	4.1
For the challenge or sport	2.7	3.1	18.6	35.6	40.1	340	4.1
To experience unpolluted natural surroundings	2.9	4.6	19.7	30.8	42.0	333	4.0
To get away from the regular routine	2.6	5.6	23.0	36.3	32.6	336	3.9
To be outdoors	1.8	5.5	18.1	42.1	32.5	340	3.9
To be close to the sea	4.0	9.8	22.0	32.9	31.2	338	3.8
To get away from the demands of other people	11.8	11.6	19.9	20.7	35.9	338	3.6
To experience new and different things	8.8	10.7	28.7	28.3	23.5	339	3.5
To be with friends	7.1	10.0	30.4	37.6	14.9	339	3.4
To develop my skills	9.3	12.2	34.1	25.8	18.6	338	3.3
For family recreation	16.0	18.9	26.0	27.9	11.3	337	3.0
To obtain fish for eating	16.1	23.2	33.8	15.8	11.2	338	2.8
To obtain a "trophy" fish	31.9	16.4	24.8	11.3	15.6	338	2.6
To test my equipment	24.2	24.9	30.5	12.4	8.0	339	2.6
To win a trophy or prize	40.9	22.7	18.3	7.2	10.9	339	2.2

[1] =Not at all important, 2=slightly important, 3=moderately important, 4=very important, 5=extremely important.

Table 2.—Distribution of anglers by the extent they agree or disagree with the following statements about saltwater sport fishing ranked by mean score.

Statement	Percent by category[1] 1	2	3	4	5	n	Mean
I'm just as happy if I release the fish I catch	1.9	8.9	19.1	32.5	37.6	337	3.95
I would rather catch one or two big fish than ten smaller fish	3.6	12.8	23.3	29.7	30.7	337	3.71
I usually eat the fish I catch	4.4	13.8	17.0	39.0	25.4	335	3.66
A fishing trip can be successful even if no fish are caught	6.8	13.8	11.9	50.4	17.1	338	3.57
The bigger the fish I catch, the better the fishing trip	4.1	17.7	27.4	31.9	18.9	337	3.44
The more fish I catch, the happier I am	6.2	17.6	24.7	36.9	14.5	337	3.36
A successful fishing trip is one in which many fish are caught	8.8	30.8	26.5	25.4	7.9	333	2.91
It doesn't matter to me what type of fish I catch	12.8	34.7	16.2	28.4	7.9	336	2.84
When I go fishing, I'm just as happy if I don't catch a fish	16.2	28.2	22.5	24.6	8.5	338	2.81

[1]1=Strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree.

Table 3.—Distribution of anglers by whether selected species groups were a substitute for shark.

Species	Percent response[1]	
	No	Yes
Seatrout/red drum	62.4	37.6
King mackerel/dolphin/cobia	34.2	65.8
Snapper/grouper	35.3	64.7
Sailfish/marlin	50.0	50.0
Flounder	68.8	31.2
Tarpon/bonefish	40.1	59.9
Amberjack	47.0	53.0
Pompano/permit	63.7	36.3

[1] 32.1% of respondents agreed with the statement that there was no substitute for shark.

gesting 215,000 trips were taken in 1989 specifically for shark fishing. Alternatively, an average of 657,000 sharks/year were caught in the Gulf of Mexico from 1979 to 1989, with an average catch of 2.4 sharks per trip (when sharks were caught)[1], suggesting an average of 274,000 shark fishing trips per year for 1979-89, indicating good agreement with the 1989 estimates. When combined with our results for shark trip expenditures and consumer surplus, we estimate a total of $42,355,000 was spent in the Gulf of Mexico region during 1989 with a consumer surplus of $23,865,000 for a total use value of $66,220,000. The MRFSS also estimates 418,000 sharks were caught in the Gulf in 1989 (this represents sharks caught by all anglers, and not just those targeting sharks specifically), suggesting an equivalent value of $101/shark caught with a consumer surplus of $57 for a total use value of $158/shark caught. An estimated 362,000 sharks were landed by recreational anglers during 1989, suggesting $117/shark landed and $66 consumer surplus for a total use value of $183/shark landed. We cannot provide estimates for 1979-89, as mean expenditures and consumer surplus are unknown.

Table 4.—Percent distribution of reasons why selected species groups were not acceptable substitutes for shark.

Reason	Percent distribution							
	Seatrout, red drum	King mackerel, dolphin, cobia	Snapper, grouper	Sailfish, marlin	Flounder	Tarpon, bonefish	Amber-jack	Pompano, permit
I don't have the right tackle	2.2	3.8	2.0	14.4	0.9	7.1	2.7	3.3
No access to that type of fishing	3.1	13.8	3.3	59.1	7.4	12.4	8.9	16.1
Not challenging enough	51.9	24.3	35.7	4.6	51.2	7.0	17.2	29.2
I don't know how to catch that type	4.8	3.9	0.0	8.6	2.8	12.7	4.7	13.4
My partners don't fish for it	7.3	7.0	2.8	9.0	9.2	10.8	14.2	13.8
It is overfished	13.3	9.6	22.2	4.6	4.1	4.3	6.3	2.6
Too many regulations	15.8	21.4	18.3	3.4	0.7	5.3	5.5	2.9
Not good to eat	5.1	4.8	1.8	6.8	1.0	25.9	13.1	1.5

Table 5.—Mean expenditures from most recent shark fishing trip.

Expenditure item	Mean spent per angler (n=340)	Percent of anglers who purchased each item	Mean expense to anglers who purchased each item
Automobile transportation	$12.42	71.5	$17.38
Other transportation (airplane, taxi, etc.)	$4.62	1.8	$261.87
Boat rental	$14.79	4.4	$335.16
Boat operation	$63.94	82.1	$77.92
Boat launch/hoist fees	$1.18	17.9	$6.58
Entrance/parking fees	$2.09	7.9	$26.34
Lodging	$10.62	9.7	$109.38
Food, drinks, ice	$36.53	88.5	$41.26
Bait, tackle	$30.90	77.6	$39.79
Captain and/or charter fees	$14.68	5.6	$262.61
Other	$6.37	13.5	$74.16
Total	$197.13 ± 20.53[1]		

[1] 95% confidence interval.

Table 6.—Logistic regression model of willingness to pay for an increase in shark trip expenses[1].

Variable description	Parameter estimate and standard error	Wald chi-square value	Prob. > chi-square	Standardized estimate
Intercept	0.6796 (0.2303)	8.71	0.0032	
Bid value	-0.0208 (0.00155)	48.70	0.0001	-0.482
Total $/trip	0.00143 (0.000408)	12.28	0.0005	0.287
Years fishing for shark	0.0244 (0.0119)	4.22	0.0400	0.139

[1] Key: N=311, model chi-square=76.44, percent concordance=69.2, consumer surplus=$110.85 (calculated using a mean trip expenditure of $197.13 and 9.7 years shark fishing experience).

Discussion

When angler studies are completed on a species basis, there are often questions regarding the suitability of the sampling frame used and extent to which results can be generalized to the population level of anglers targeting that species. In this paper, there is support for using tournament shark anglers as a proxy for shark anglers. Our sample of shark anglers participate in tournaments but their shark fishing is not limited exclusively to tournaments. Furthermore, tournament shark anglers were similar in many ways to the shark club anglers studied previously by Graefe and Ditton (1976) (e.g., both groups had annual mean fishing frequencies >50 days). Finally, there may be no alternative to using the sampling frame of tournament shark anglers. While it may be possible to expand sampling coverage under the MRFSS to intercept more anglers targeting sharks, the costs involved may far outweigh the biases associated with sampling tournament anglers. Perhaps the estimated gross economic value of the shark fishery will provide support for using a more representative and costly approach to sampling shark anglers in support of fisheries management.

When the motivations and attitudes of this group of shark anglers are com-

pared to those of members of the Corpus Christi Shark Association (Graefe and Ditton, 1976), there are similarities and differences. Both groups placed great importance on the nonconsumptive aspects of fishing, notably challenge and the experience of the catch, and much less importance on fishing as a means to obtain fish for eating or to obtain a "trophy" fish. Neither group was highly motivated to participate in fishing as family recreation.

When tournament shark anglers are compared to the general population of saltwater anglers in Texas (Ditton et al., 1991), for example, there is good evidence to suggest that high specialization anglers are overrepresented in the shark angler group. First, shark anglers have a three times higher annual fishing frequency and are three times more likely to rate themselves as more skilled than saltwater anglers in general. Second, although younger on average, shark anglers have roughly the same average number of years of saltwater fishing experience. Third, as an indicator of their greater resource dependency, shark anglers are more interested in catching big fish than the general population of saltwater anglers. Also, approximately one-third of the former group were sufficiently committed to shark fishing that they were unwilling to substitute another big fish species. Finally, shark anglers attribute more importance to the challenge aspects of catching fish than saltwater anglers in general; likewise, shark anglers have less interest in numbers of fish caught or their retention for food or other purposes. Shark anglers are intimately involved in fishing for big fish, and for many it is probably a central life interest. Furthermore, we found shark anglers to be similar to billfish anglers in the U.S. Atlantic (Fisher and Ditton, 1992). Results suggest both angler groups share the need for challenging, big-fish fishing experiences, but shark anglers who are unwilling to substitute billfish for sharks lack the financial means to pursue billfishes.

Proposed regulations should have minimal impact on the recreational shark fishery. Most shark trips occur in state waters and probably target both small and large coastal sharks; proposed regulations would allow a maximum catch of 5 sharks/person/day and 4 sharks/boat/trip, respectively. Historically, the Gulf of Mexico recreational shark fishery releases most of its catch[1], and our results suggest most anglers do not reach the bag limit. Sharks represent the last of the big fish species to be regulated; all other large species that were acceptable substitutes for sharks are subject to bag limits or annual quotas. Closure of one fishery, e.g., king mackerel, may cause anglers to devote more effort to sharks in order to satisfy their motivation for the challenge of catching a big fish. If shark regulations become more restrictive in the future, big fish anglers may curtail their fishing activity or stop altogether.

We found no evidence of a major directed party boat shark fishery in Port Aransas, Tex., as reported in the proposed shark FMP[1]. Our sampling effort revealed few anglers targeting sharks. We found sharks to be a by-catch fishery for party boat anglers hoping to catch "something." Furthermore, we have reservations about data that show the Port Aransas party boat fishery landing an average of 92 metric tons of sharks per year from 1987 to 1989[1]. Each shark weighed an average of 5.7 kg for an average of over 16,000 sharks landed per year, or 44 sharks per day. Approximately half of these sharks were Atlantic sharpnose, *Rhizoprionodon terraenovae*. From 50 to 75% were landed between June and August, necessitating an average of 88-132 sharks landed per day in Port Aransas during this period[1]. These figures do not agree with our observations, those of the party boat operators, or McEachron (1984). McEachron's estimates of party boat shark landings from the Port Aransas area (Aransas Bay to Upper Laguna Madre) during 1979-83 were an order of magnitude less than the estimates for Port Aransas[1]. One Port Aransas party boat operator keeps a photographic record of his daily catches; species and numbers are easily identifiable, and his 1991 landings do not reflect the magnitude of the landings or species composition reported in the proposed shark FMP[1]. Other Port Aransas party boat operators report they primarily target king mackerel, snapper, and grouper during June-August and land sharks as bycatch.

Our estimate of the gross value of the recreational fishery should be considered a conservative estimate. We calculated our results using trips specifically targeting sharks as estimated by the MRFSS. Trips not targeting sharks but resulting in sharks being caught were not included in our estimate. While we extrapolate the value of all directed shark trips in the Gulf of Mexico, we have no estimate of the value of a trip where sharks are caught incidentally. Thus, our results are an underestimate of the total value of the recreational shark fishery. Nevertheless, the gross use value of the Gulf of Mexico recreational shark fishery would appear to justify the $500,000 annual cost of enforcement of the commercial and recreational shark regulations[1]. Also, it is reasonable to expect the value of the recreational fishery to increase as stocks rebuild, creating an increase in net benefits to the nation when management costs are subtracted. Finally, we would recommend further research to clarify the various issues on data needs mentioned in the preceding paragraph.

Acknowledgments

Partial funding support for this project was provided by the Southeast Regional Office, National Marine Fisheries Service, NOAA, under the MARFIN program (Contract No. NA90AA-H-MF756). Robert Hueter of the Mote Marine Laboratory provided lists of shark tournaments and names and addresses of shark anglers from the eastern Gulf of Mexico. We acknowledge the cooperation of the shark tournament directors who provided access to our sample and shark anglers who voluntarily provided us with the data requested. We appreciate the cooperation provided by Captain Paul Dirk, who provided us with access to party boat anglers at Dolphin Docks in Port Aransas, Tex. Assistance was provided by Bo Shelby and Jerry Vaske with the species substitution question. Finally, we acknowledge the careful and thoughtful

reviews provided by Steve Branstetter, George Burgess, Robert Hueter, and Robin Riechers.

Literature Cited

Agresti, A. 1990. Categorical data analysis. John Wiley and Sons, N.Y., 558 p.

Bell, F. W., P. E. Sorensen, and V. R. Leeworthy. 1982. The economic impact and valuation of saltwater recreational fisheries in Florida. Fla. Sea Grant Prog., Gainesville, Rep. 47, 367 p.

Bethlehem, J. G., and H. M. P. Kersten. 1985. On the treatment of nonresponse in sample surveys. J. Off. Stat. 1:287-300.

Bishop, R. C., and T. A. Heberlein. 1979. Measuring values of extra-market goods: Are indirect measures biased? Am. J. Agric. Econ. 61:926-930.

Bryan, H. 1977. Leisure values systems and recreational specialization: The case of trout fishermen. J. Leis. Res. 9:174-187.

Cochran, W. G. 1977. Sampling techniques. John Wiley and Sons, N.Y., 428 p.

Dillman, D. A. 1978. Mail and telephone surveys: The total design method. John Wiley and Sons, N.Y., 325 p.

Ditton, R. B., K. M. Hunt, S. Choi, M. F. Osborn, R. Riechers, and G. C. Matlock. 1991. Trends in demographics, participation, attitudes, expenditures and management preferences of Texas saltwater anglers, 1986-1987. Tex. Parks Wildl. Dep., Fish. Wildl. Div., Manage. Data Ser. 79, 75 p.

_____, D. K. Loomis, and S. Choi. 1992. Recreation specialization: Reconceptualization from a social worlds perspective. J. Leis. Res. 24:33-51.

Fisher, M. R., and R. B. Ditton. 1992. Characteristics of billfish anglers in the U.S. Atlantic Ocean. Mar. Fish. Rev. 54(1):1-6.

Graefe, A. R. 1980. The relationship between level of participation and selected aspects of specialization in recreational fishing. Tex. A&M Univ., Coll. Sta. Ph.D. dissert.

_____ and R. B. Ditton. 1976. Recreational shark fishing on the Texas Gulf Coast: An exploratory study of behavior and attitudes. Mar. Fish. Rev. 38(2):10-20.

Hendee, J. C., and R. S. Burdge. 1974. The substitutability concept: Implications for recreation research and management. J. Leis. Res. 6:157-162.

Huppert, D. D. 1983. NMFS guidelines on economic valuation of marine recreational fishing. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-32, 35 p.

Kalton, G. 1983. Compensating for missing survey data. Inst. Soc. Res., Univ. Mich., Ann Arbor, 158 p.

McEachron, L. W. 1984. Harvest estimates for Texas marine charter boats (1978-1982). Tex. Parks Wildl. Dep., Tech. Ser. 29, 90 p.

NMFS. 1991. Marine recreational fishery statistics survey, Atlantic and Gulf coasts, 1987-1989. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Curr. Fish. Stat. 8904, 363 p.

Parrack, M. L. 1990. A study of shark exploitation in the U.S. Atlantic coastal waters during 1986-1989. Natl. Mar. Fish. Serv., St. Petersburg, Fla., Contrib. MIA-90|91-03, 28 p.

Shelby, B., and J. J. Vaske. 1991. Resource and activity substitutes for recreational salmon fishing in New Zealand. Leis. Sci. 13:21-32.

Vaske, J. J. 1980. An empirical comparison of methodological approaches to recreational substitutability. Univ. Md., College Park, Ph.D. dissert.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1994 -- 589-087 / 80002 REGION NO. 10

UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SCIENTIFIC PUBLICATIONS OFFICE
BIN C15700
SEATTLE, WA. 98115
OFFICIAL BUSINESS

Penalty for Private Use, $300

Second-Class Mail
Postage and Fees Paid
U.S. Department of Commerce
ISSN 0090-1830

UNIV MICROFILMS INTERNATL M
300 N. ZEEB RD/P.O. BOX 1346
ATT: SER. ACQUISITIONS DEPT
ANN ARBOR, MI 48106-1346